Model 493.10/793.00 Controller Service

100-068-901 E

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The status and validity of MTS' operating software is also checked during system verification and routine calibration of MTS hardware. These controlled calibration processes compare the final test results after statistical analysis against the predicted response of the calibration standards. With these established methods, MTS assures its customers that MTS products meet MTS' exacting quality standards when initially installed and will continue to perform as intended over time.

Publication information

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Preface

Safety first!

Before you attempt to use your MTS product or system, read and understand the *Safety* manual. Like an automobile, your test system is very useful—but if misused, it is capable of deadly force. You should always maintain a healthy respect for it.

Improper installation, operation, or maintenance of MTS equipment in your test system can result in hazardous conditions that can cause severe personal injury or death, and damage to your equipment and specimen. Again, read and understand the *Safety* manual before you continue. It is very important that you remain aware of hazards that apply to your system.

Other MTS manuals

In addition to this manual, you may receive additional MTS manuals in paper or electronic form.

If you have purchased a test system, it may include an *MTS System Documentation CD*. This CD contains an electronic copy of all MTS manuals that pertain to your test system, including controller manuals, hydraulic and mechanical component manuals, assembly drawings and parts lists, and operation and preventive maintenance manuals.

Contents

Conventions

The following paragraphs describe some of the conventions that are used in your MTS manuals.

Hazard conventions

As necessary, hazard notices may be embedded in this manual. These notices contain safety information that is specific to the task to be performed. Hazard notices immediately precede the step or procedure that may lead to an associated hazard. Read all hazard notices carefully and follow the directions that are given. Three different levels of hazard notices may appear in your manuals. Following are examples of all three levels.

Note *For general safety information, see the Safety manual included with your system.*

Danger notices

Danger notices indicate the presence of a hazard which *will* cause severe personal injury, death, or substantial property damage if the danger is ignored. For example:

DANGER

High intensity light and dangerous radiation are emitted by class 3B lasers.

Viewing a class 3b laser directly or viewing it using optical instruments will cause immediate and severe injury.

Avoid eye or skin exposure to the laser beam. Ensure that all power to the laser is off before attempting any maintenance, service, or adjustment procedures.

Warning notices

Warning notices indicate the presence of a hazard which *can* cause severe personal injury, death, or substantial property damage if the warning is ignored. For example:

WARNING

Hazardous fumes can accumulate in the test chamber as a result of testing.

Breathing hazardous fumes can cause nausea, fainting, or death.

Ensure that the chamber is properly ventilated before you open the chamber door or put your head or hands into the chamber. To do this, ensure that the temperature controller is off and allow sufficient time for the ventilation system to completely exchange the atmosphere within the chamber.

Caution notices

Caution notices indicate the presence of a hazard which *will* or *can* cause minor personal injury, cause minor equipment damage, or endanger test integrity if the caution is ignored. For example:

CAUTION

This specimen can develop sharp edges as a result of testing.

Handling the specimen with unprotected hands can result in cuts and slivers.

Always wear protective gloves when you handle the specimen.

Other conventions

Other conventions used in your manuals are described below:

Notes

Notes provide additional information about operating your system or highlight easily overlooked items. For example:

Note *Resources that are put back on the hardware lists show up at the end of the list.*

Special terms

The first occurrence of special terms is shown in *italics*.

Illustrations

Illustrations appear in this manual to clarify text. It is important for you to be aware that these illustrations are examples only and do not necessarily represent your actual system configuration, test application, or software.

Electronic manual conventions

This manual is available as an electronic document in the Portable Document File (PDF) format. It can be viewed on any computer that has Adobe Acrobat Reader installed.

Hypertext links

The electronic document has many hypertext links displayed in a blue font. All blue words in the body text, along with all contents entries and index page numbers are hypertext links. When you click a hypertext link, the application jumps to the corresponding topic.

Technical Support

Start with your manuals

The manuals supplied by MTS provide most of the information you need to use and maintain your equipment. If your equipment includes MTS software, look for README files that contain additional product information.

If you cannot find answers to your technical questions from these sources, you can use the internet, telephone, or fax to contact MTS for assistance. You can also fill out the Problem Submittal Form that is available on the MTS web site and in the back of many MTS manuals that are distributed in paper form.

Technical support numbers

MTS provides a full range of support services after your system is installed. If you have any questions about a system or product, contact MTS in one of the following ways.

MTS web site www.mts.com

The MTS web site gives you access to our technical support staff by means of a Problem Submittal Form and a Technical Support link.

- Problem Submittal Form:
  www.mts.com > Contact MTS > Problem Submittal Form
- Technical Support:
  www.mts.com > Contact MTS > Technical Support

E-mail:

info@mts.com

Telephone

HELPLine 800-328-2255
Weekdays 7:00 A.M. to 6:00 P.M.,
Central Time

Fax

952-937-4515
Please include an MTS contact name if possible.

Preface

Before you contact MTS

MTS can help you more efficiently if you have the following information available when you contact us for support.

Know your site number and system number

The site number contains your company number and identifies your equipment type (material testing, simulation, and so forth). The number is usually written on a label on your MTS equipment before the system leaves MTS. If you do not have or do not know your MTS site number, contact your MTS sales engineer.

Example site number: 571167

When you have more than one MTS system, the system number identifies which system you are calling about. You can find your job number in the papers sent to you when you ordered your system.

Example system number: US1.42460

Know information from prior technical assistance

If you have contacted MTS about this problem before, we can recall your file. You will need to tell us the:

- MTS notification number
- Name of the person who helped you

Identify the problem

Describe the problem you are experiencing and know the answers to the following questions.

- How long has the problem been occurring?
- Can you reproduce the problem?
- Were any hardware or software changes made to the system before the problem started?
- What are the model and serial numbers of the suspect equipment?

Know relevant computer information

If you are experiencing a computer problem, have the following information available.

- Manufacturer's name and model number
- Operating software type and service patch information. Examples:
  - Windows XP Service Pack 1 (SP1)
  - Windows 2000 Service Pack 3 (SP3)
  - Windows NT 4.0 Service Pack 7 (SP7)
- Amount of system memory. Example: 640 MB of RAM.
- Amount of free space on the hard drive in which the application resides. Example: 11.2 GB free space, or 72% free space.
- Current status of hard-drive fragmentation. Example: 3% total fragmentation.

Know relevant software information

For software application problems, have the following information available.

- The software application's name, version number, build number, and if available, software patch number. This information is displayed briefly when you launch the application, and can typically be found in the "About" selection in the "Help" menu.

  Example: Station Manager, Version 3.3A, Build 1190, Patch 4
- It is also helpful if the names of other non-MTS applications that are running on your computer, such as screen savers, keyboard enhancers, print spoolers, and so forth are known and available.

If you contact MTS by phone

Your call will be registered by a HELPLine agent if you are calling within the United States or Canada. Before connecting you with a technical support specialist, your agent will ask you for your site number, name, company, company address, and the phone number where you can normally be reached.

Identify system type

To assist your HELPLine agent with connecting you to the most qualified technical support specialist available, identify your system as one of the following types:

- Electromechanical materials test system
- Hydromechanical materials test system
- Vehicles test system
- Vehicles component test system
- Aero test system

Be prepared to troubleshoot

Prepare yourself for troubleshooting while on the phone.

- Call from a telephone close to the system so that you can try implementing suggestions made over the phone.
- Have the original operating and application software media available.
- If you are not familiar with all aspects of the equipment operation, have an experienced user nearby to assist you.

Write down relevant information

Prepare yourself in case we need to call you back.

- Remember to ask for the notification number.
- Record the name of the person who helped you.
- Write down any specific instructions to be followed, such as data recording or performance monitoring.

After you call

MTS logs and tracks all calls to ensure that you receive assistance and that action is taken regarding your problem or request. If you have questions about the status of your problem or have additional information to report, please contact MTS again.

Problem Submittal Form in MTS manuals

In addition to the Problem Submittal Form on the MTS web site, there is also a paper version of this form (postage paid) in the back of many MTS manuals. Use this form to communicate problems you are experiencing with your MTS software, hardware, manuals, or service. This form includes check boxes that allow you to indicate the urgency of your problem and your expectation of an acceptable response time. We guarantee a timely response—your feedback is important to us.

Chapter 1

Introduction

The Model 493.10 Chassis is a multi-station, multi-channel VMEbus chassis which houses up to ten MTS VMEbus modules in its front panel and up to ten transition modules in its rear panel. The chassis supports up to four stations and eight channels in a standard configuration.

Optional six and eight station models are available.

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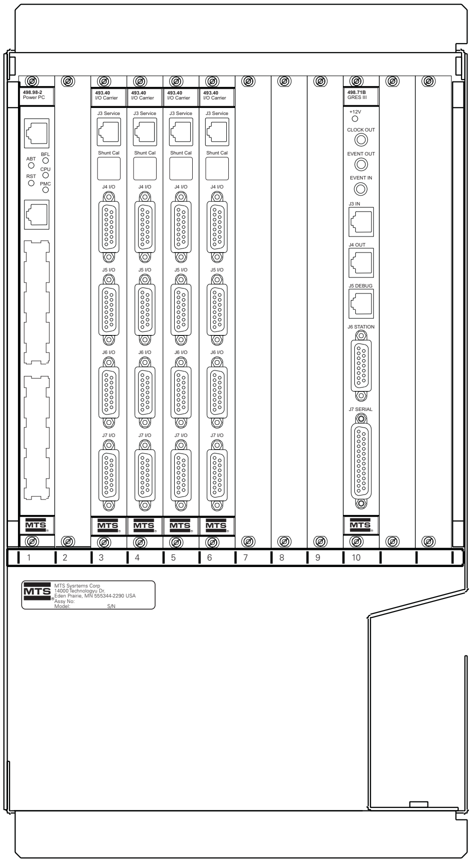
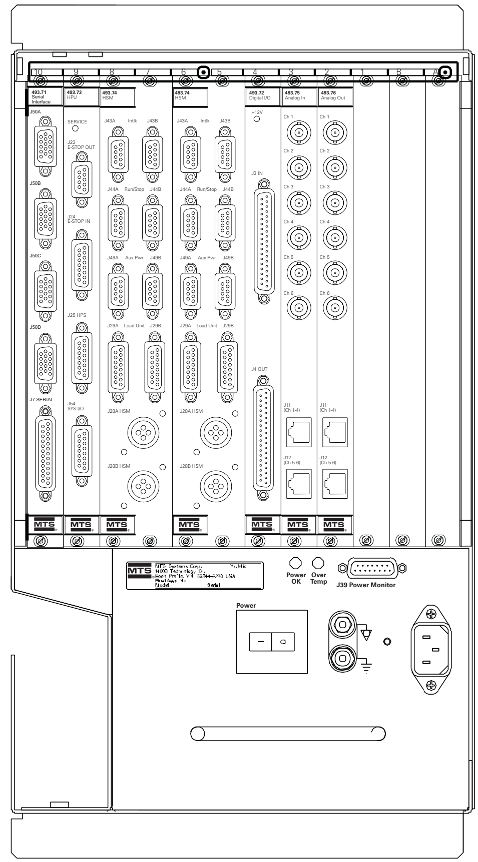


Front Panel (with VMEbus Modules)



Rear Panel (with Transition Modules)

What you need to know

MTS Systems Corporation assumes you are familiar with the other components of your system. You are expected to know how to perform the following:

- Ground yourself to the chassis
- Handle sensitive electronic components
- Connect and secure cables
- Plug circuit card modules into chassis guides

Related products

The Model 493.10 chassis is part of a test system. The chassis is controlled by a personal computer and the controller software is

installed on the computer. See your controller software documentation for information about the test system use

Inappropriate use

Before you install the Model 493.10 Chassis, read and understand this manual before installing this product. Improper installation or operation of this product can result in hazardous conditions that can cause severe personal injury or death, and damage your equipment and specimen.

Functional Description

The Model 493.10 Chassis front panel has twelve slots, ten VMEbus slots and two slots (a and b) which are reserved. The rear panel of the chassis has twelve transition bus slots. Two of these rear panel slots (slots A and B) can not be used with powered MTS transition modules. The chassis can be rack mounted or used in a floor standing configuration.

VMEbus

The chassis has ten VMEbus slots that support a variety of MTS VMEbus plug-in modules. A typical complement of modules would include:

- The chassis requires at least one processor module. The processor module provides the processing power to manage the other plug-in modules that make up the controller.
- The chassis can have up to eight I/O Carrier modules. Each I/O Carrier module supports up to four daughter boards.
- An optional GRES module provides several connections to communicate with external devices such as a remote station control module, temperature controller, and other devices.

Transition bus

Transition modules are panels plugged into the transition bus located in the rear of the chassis. Each transition module allows external devices to interface with the chassis. Transition modules provide the following:

- Hydraulic control connections
- Station control connections
- Analog input and output connections
- Digital input and output connections
- Serial connections

Cable conduit

The chassis has a conduit that allows cables to be routed from the front VMEbus modules to the rear transition modules and out of the chassis.

Power supply

Two power supplies are used. One provides +5 VDC and ±15 VDC for the plug-in modules; the other provides ±12 VDC for plug-in modules and +24 VDC for hydraulic power and the chassis fan. The power supplies have universal inputs and will adapt to any line voltage between 90 and 264 VAC.

The power supply is protected with an external circuit breaker in the On/Off switch that trips at a 10 ampere overload. An internal fuse in the power supply is not user accessible or repairable.

Cooling

The chassis is cooled with a fan. An overtemperature sensor is part of the standard power supply assembly. If the internal chassis temperature exceeds 50°C, this sensor will light an amber indicator located on the rear of the power supply module

Hydraulic control

Hydraulic control is handled with two transition modules.

The Model 493.73 HPU Transition module has a connection to control a hydraulic power unit. It includes connections for an emergency stop button and digital I/O for system communications.

Typically, up to four Model 493.74 HSM transition modules can be used to support up to eight HSM stations. Each HSM module includes connections to support two stations. Each station supports an HSM, a load unit, run/stop outputs, auxiliary outputs, and interlock controlled outputs.

Interlocks

Two types of interlocks are supported, the system wide interlock and station interlocks. The system wide interlock shuts down the hydraulic power unit and all stations, and the station interlock shuts down a single station leaving other stations running. The emergency stop function on the Model 493.74 HSM transition board contains two separate circuits, the system wide interlock (HPU) and the station interlock (HSM).

System wide interlock

The emergency stop circuit consists of a loop that only runs through the rear panel transition boards of the chassis. Any board that generates an interlock by breaking this system wide loop causes the hydraulic power unit to be shut down. This will also cause all of the stations to shut down.

Note *The emergency stop circuit meets the requirements of the Machinery Safety Directive (EN 60204-1, 1992, section 9.2.5.4). This means the emergency stop circuit is hard-wired with electromechanical components.*

Introduction

Station interlocks

Each station represents all of the components associated with an interlock chain. All of the modules plugged into the chassis can be assigned to stations. If one of the stations generates an interlock, all of the components assigned to the station are shut down.

Standard configurations support up to four independent stations.

Specifications

Parameter	Specification
Environmental	For indoor use only
Temperature	5–40°C (41–104°F)
Relative humidity	10–85%, noncondensing
Altitude	For use at altitudes up to 2000 m (6500 ft)
Power input	power factor corrected universal input
Input voltage*	100–240 V AC
Input frequency	47–63 Hz
Input surge	<100 A
Power	< 1000 W
Insulation over voltage	Category II
Pollution degree	2
Power supply #1	maximum draw is 400 W total
+5 VDC	40 A
±15 VDC	7.5 A
Power supply #2	maximum draw is 400 W total
±12 VDC	4 A
+24 VDC	10 A
Weight	approximately 45 kg (100 lb) in stand alone configuration

* The specification shown conforms to CE Low Voltage Directive requirements. The specification allows for 10% of the values stated. The actual voltage the 493.10 chassis can operate is 90–264 V AC.

Chapter 2
Installation

This section describes how to install the Model 493.10 Chassis and connect it to your system components.

Contents

Installation

Installing the Chassis

The chassis can be installed in an equipment rack console or in a stand-alone configuration.

CAUTION

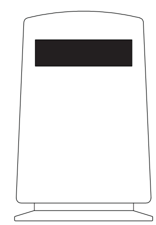
The Model 493.10 Chassis weighs about 45 kg (100 lb) in stand alone configuration.

Improper lifting techniques can cause strained muscles and back injuries.

When lifting this chassis, take the appropriate precautions to prevent injuries to yourself.

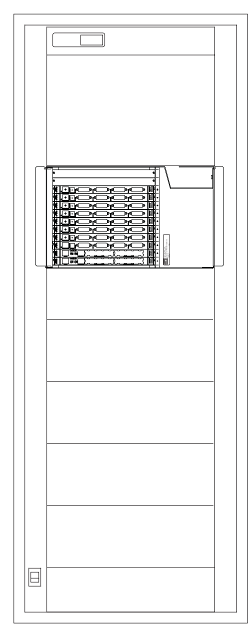
Stand-alone installation

The stand-alone chassis can be placed on the floor. The chassis location is limited only by the length of the system cables. The front panel of the chassis can be removed to access the VMEbus plug-in modules.



Console installation

The rack-mounted chassis can be installed in any Model 490.8x console. Install the console with the 493.10 Rack Mounting kit (part number 561395-01 for TestStar IIm or 561395-02 for FlexTest GT). The Rack Mounting kit provides the hardware (L-shaped brackets) to support the chassis and mounting screws to secure the chassis to the console rack.



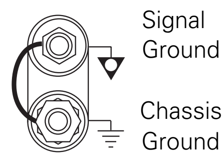
Connecting Electrical Power

Electrical connections must be made by qualified personnel and conform to local codes and regulations. An electrical service panel to provide the electrical power feed (line voltage) to the chassis is not necessary, but may be required by local electrical codes.

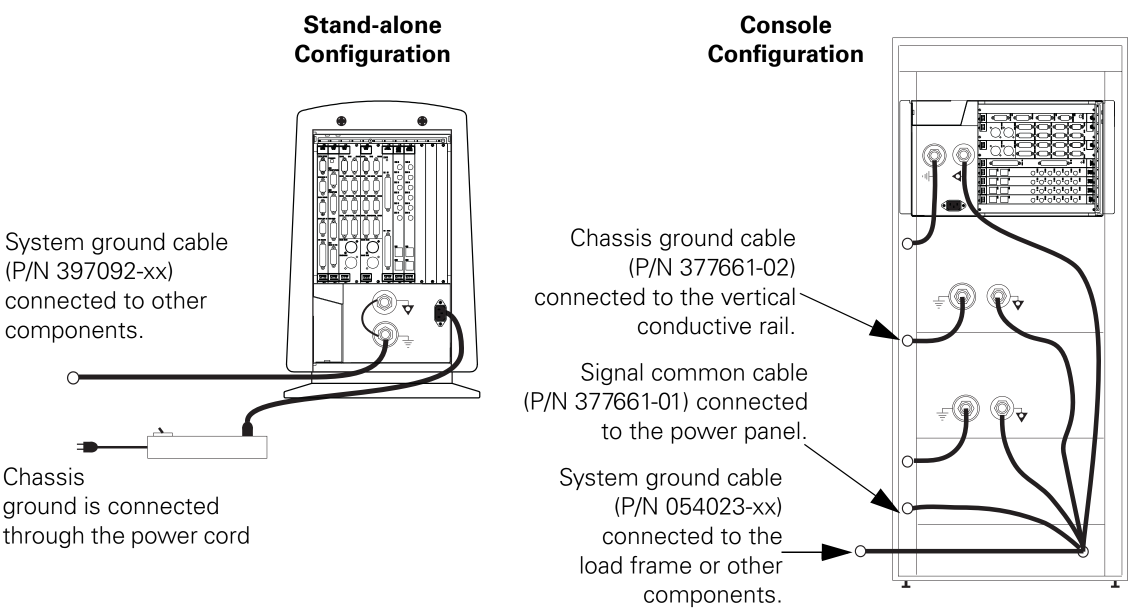
Note *Local electrical codes supersede any information found here.*

Grounding

The chassis will not function correctly if it is not grounded as shown. Be sure your power source is also properly grounded. The chassis includes two grounds: a chassis ground and a signal ground. The two grounding lugs are connected together with an external shorting bar when the chassis is manufactured.



- For the console configuration, remove the shorting bar from the ground lugs and connect the chassis ground to the console rail.
- For a stand-alone configuration, always connect the shorting wire to both ground lugs.



AC grounding

The AC power ground is through the power cord. The power cord must be plugged into both the chassis and the power source for proper grounding.

⚠ CAUTION

Proper grounding is required for safe operation.

It is also required to meet EMC emission and susceptibility requirements.

Power

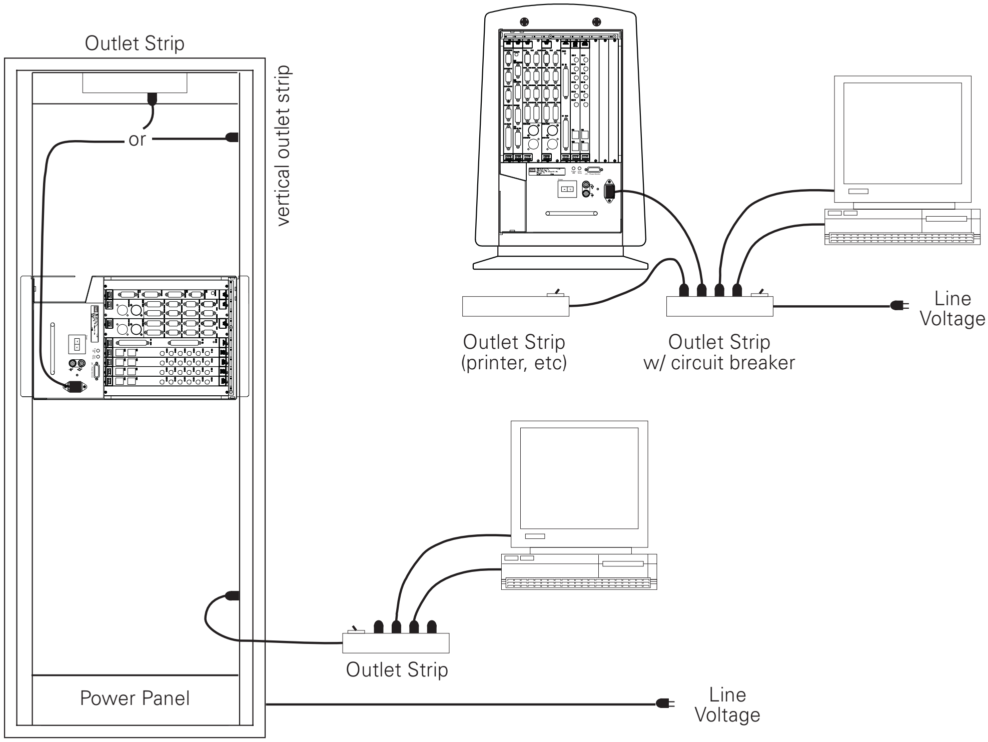
All equipment related to the chassis should be connected on the same fused power circuit.

- The power supply can accept single-phase voltages within 90–264 V AC at frequencies between 47–63 Hz.
- The maximum continuous power usage is approximately 1000 W. The current draw depends on the local voltage supply. A 15 amp line should be adequate for the chassis and the computer.
- The power supply automatically selects the proper voltage range and line frequency.
- The power supply is protected with an external circuit breaker in the On/Off switch that trips at a 10 ampere overload. An internal fuse in the power supply is not user accessible or repairable.
- An outlet strip is supplied with the floor-standing chassis.
- The computer components may be plugged directly into the outlet strip of a vertical console or a floor-standing console.

AC power disconnect

Turn off the AC power switch. Remove the AC power cord from the unit. This will remove all AC power from the 493.10 chassis.

Note *Be sure to locate the chassis so you have adequate access to disconnect the power cord from the chassis.*


Outlet Strip
or
vertical outlet strip
Power Panel
Outlet Strip
Line
Voltage
Outlet Strip
(printer, etc)
Outlet Strip
w/ circuit breaker
Line
Voltage

Installing the Plug-in Modules

This section describes how to install the plug-in modules into the chassis. The modules plug into a backplane connector and are secured to the chassis with a screw at the top and at the bottom of the module faceplate.

A hardware interface file (.hwi) defines each type of module and maps each module location for the system software. The .hwi file and the physical locations for each type of module must match. Recommended standard module locations are described in the following sections. For more information on the .hwi file, see "The .HWI File" on page 283.

CAUTION

The plug-in modules contain static-sensitive components.

Improper handling of the module can cause component damage.

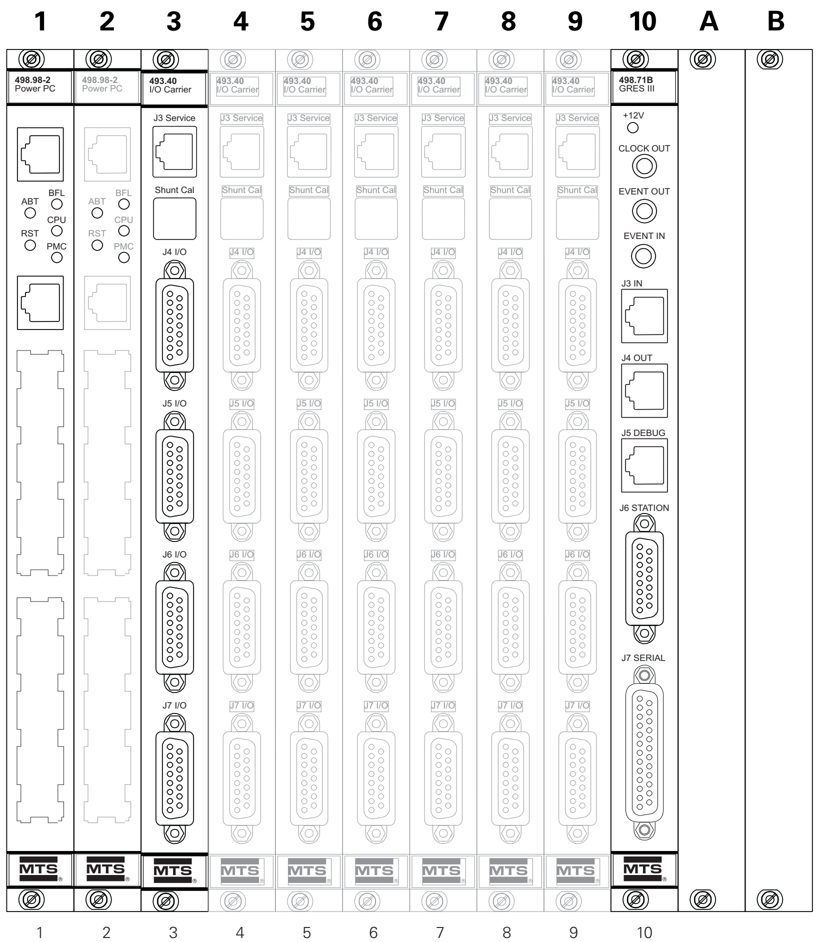
Be sure to follow these precautions when handling modules:

- Turn off electrical power before installing or removing a module.
- Use a static ground strap to ground yourself to the chassis ground before touching the chassis or a module.
- Keep unused modules in conductive bags. Also be sure you are grounded when removing a module from a conductive bag.
- Handle modules with their front panel or circuit card edges. Do not touch any circuit card components, pins, or circuit connection points.

VMEbus Modules

The VMEbus compatible modules should be installed in the front panel chassis slots according to the following guidelines.

- The processor module(s) must be located in the first (and second) slots.
- The GRESIII module (if used) should be located in slot 10. It may also be located in slot 2 if a second processor is not used. See "GRES III" on page 309.
- I/O carrier modules and/or ADDA II modules can be installed in slots 3 to 10. Install a module in slot 3 and any additional modules to the right of it.



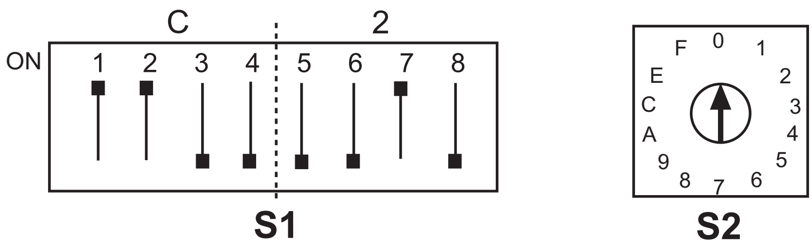
Setting I/O Carrier addresses

Use the dipswitch (S1) and rotary dipswitch (S2) on each I/O Carrier module to set its address in accord with its installed chassis slot as follows:

Slot Number	1	2	3	4	5	6	7	8	9	10
Address	PPC		C20	C22	C24	C26	C28	C2A	C2C	C2E

The dipswitch settings for address C20 is shown below. Increment the rotary dipswitch as required to complete I/O Carrier module addressing..

Installation

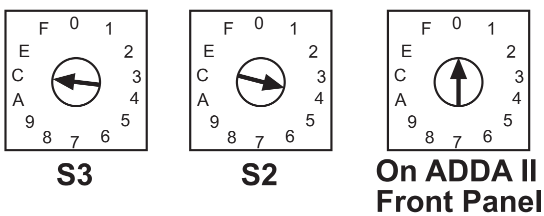


Setting ADDA II addresses

Use the onboard rotary dipswitches (**S3, S2)** and front panel rotary dipswitch on each ADDA II module to set its address in accord with its installed chassis slot as follows:

Slot Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Address	**PPC**	**PPC**		**C40**	**C41**	**C42**	**C43**	**C44**	**C4A**	**C4C**

The dipswitch settings for address C40 are shown below. Increment the front panel dipswitch as required to complete ADDA II module addressing.



Front Panel VMEbus Modules

Model	Module Name	Function
493.40	**I/O Carrier**	Supports up to four daughter boards.
493.50	**ADDA II**	This optional module supports up to four 8-channel A/D (Model 493.55) or D/A (Model 493.56) daughter boards. This module also supports the 8-channel DSPAD, 8-channel Delta-Sigma A/D, and 4-channel Universal Encoder daughter cards.
498.96-2/ 4989.96-3	**Processor**	Provides an interface between the controller and an external computer. The processor module also manages the plug-in modules and transition panels.
498.71B	**GRES III**	Interfaces with a Remote Station Control (RSC) module and temperature controllers.

I/O Carrier Daughter Boards

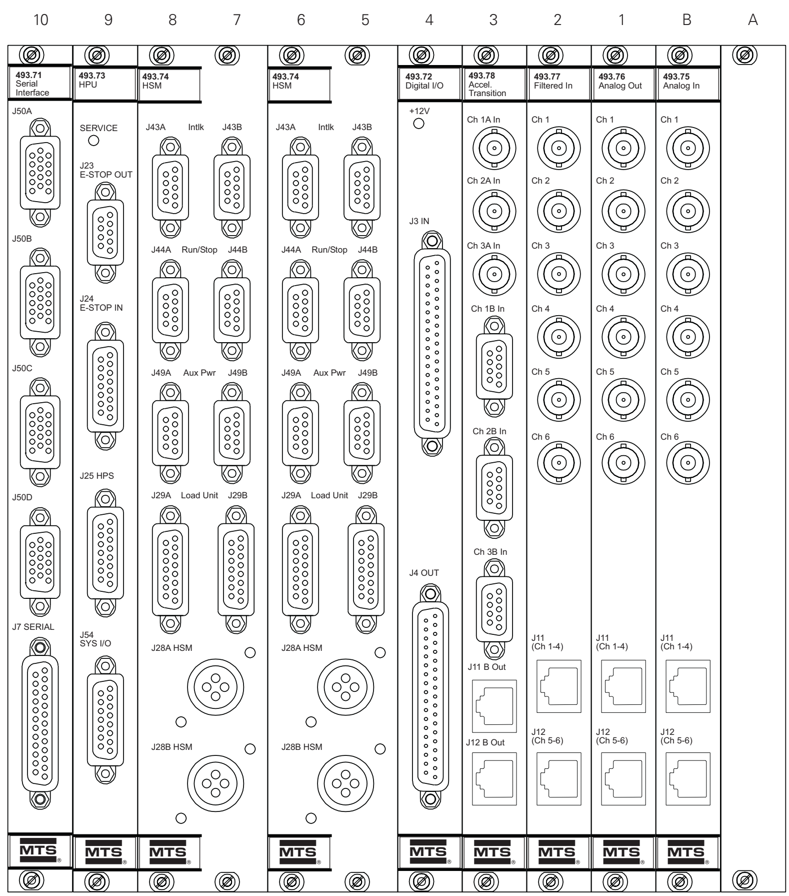
Model	Module Name	Function
493.14	**Valve Driver**	Produces the control signal for a Series 252 Servovalve.
493.15	**3–Stage Valve Driver**	Produces the control signal for a Series 256 or 257 Servovalve.
493.21B	**Universal Conditioner**	Processes the signals from either an AC or DC-type sensors.
493.25	**Universal Conditioner**	Processes the signals from either an AC or DC-type sensors.
493.45	**A/D**	Converts up to six external analog signals to digital signals for use by the controller.
493.46	**D/A**	Converts up to six internal digital signals to analog signals for use by external devices.
493.47	**Encoder**	Processes the signals from an encoder or a Temposonics III transducer with an SSI interface.
493.48	**Acceleration Conditioner**	Processes the signals from an accelerometer. Each Acceleration Conditioner daughter board can support up to three accelerometers. Before installing this board, specific jumpers must be set on the I/O Carrier module. See "I/O Carrier jumper settings" on page 52 for more information on jumper settings.

ADDA II Daughter Boards

Model	Module Name	Function
493.55	**A/D**	Converts up to eight external analog signals to digital signals for use by the controller. This board requires the optional ADDA II module.
493.56	**D/A**	Converts up to eight internal digital signals to analog signals for use by external devices. This board requires the optional ADDA II module.
493.57	**DSPAD**	Converts up to eight external analog signals to digital signals for use by the controller. A DSP chip provides digital filtering. This board requires the optional ADDA II module.
493.59	**Universal Encoder**	Processes the signals from incremental, absolute, and Temposonics III encoders. This board requires the optional ADDA II module.

Transition Panels

The transition panels need to be installed in specific slots of the rear panel chassis. This is done to allow proper air flow in the chassis. For consistency, install the modules according to the following guidelines. Starting from the left chassis slot (slot 10) and working to the right, install the modules as shown. If you do not have one of the modules, install the next one you do have. Install multiple modules of the same model number next to each other.



Note *Other transition modules may be used, contact MTS Systems Corporation for additional information.*

Installation

Rear Panel Transition Panels

Model	Module Name	Function
493.71	**RS485**	Provides four channels of RS-485 interface, four channels of station stop interlocks, and four channels of emergency stop interlocks. The RS-485 interface channels are used for the Remote Station Controller and/or temperature controller.
493.72	**Digital I/O**	Contains sixteen general purpose digital input channels and sixteen general purpose digital output channels.
493.73	**HPU Transition Board**	Interfaces the controller with a hydraulic power unit.
493.74	**HSM Transition Board**	Interfaces the controller with a hydraulic service manifold and other devices, up to two stations.
493.75	**Analog In BNC**	Provides six BNC channels for analog input signals. The input signals must be within ±10 V DC.
493.76	**Analog Out BNC**	Provides six BNC channels for analog output signals. The output signals are within ±10 V DC.
493.77	**Filtered Analog Input**	Provides filtering for the Model 493.45 A/D (analog-to-digital) modules.
493.78	**Accelerometer Transition Board**	Interfaces with up to three low impedance voltage mode (LIVM) accelerometers and three signal conditioned type accelerometers.
493.79	**Multiple Universal Driver Board**	Provides up to six drivers that can be used to drive standard 252 servovalves. Inputs to this board can originate from either a ADDA II board (6 outputs) or a Model 493.46 D/A board (6 outputs).
493.80	**Encoder Transition**	Interfaces with up to four encoders.
493.81	**Analog In BNC**	Provides up to eight channels of analog input to each Model 493.55 A/D module. The input signals must be within ±10 V DC.
493.82	**Analog Out BNC**	Provides eight channels of analog output from the Model 493.56 D/A modules. The output signals are within ±10 V DC.
493.83	**Filtered Analog Input**	Provides up to eight channels of filtered analog input to each Model 493.55 A/D module.

Chapter 3

Cabling

This section describes the cable connections to the Model 493.10 Chassis.

Note *For information on connecting power cables, see* *"Connecting Electrical Power" on page 27.*

Contents

CE EMC Compliant Cabling

CE EMC compliant cabling is required for all systems shipped to Europe. All cabling specifications in this chapter conform to the European CE EMC requirements.

Cable fabrication

All of the cables listed on the Cable Selector drawing are CE EMC compliant when used in an MTS system. Where possible, use standard cables listed on the System Cable/Jumper Plug 493 Package Selection drawing (PN 700-000-656). If it is not possible to use standard cables or you are constructing custom cables, select cables, backshells, and connection shields as described in the cable specification for each connector. See the appropriate rear panel connector for fabrication information.

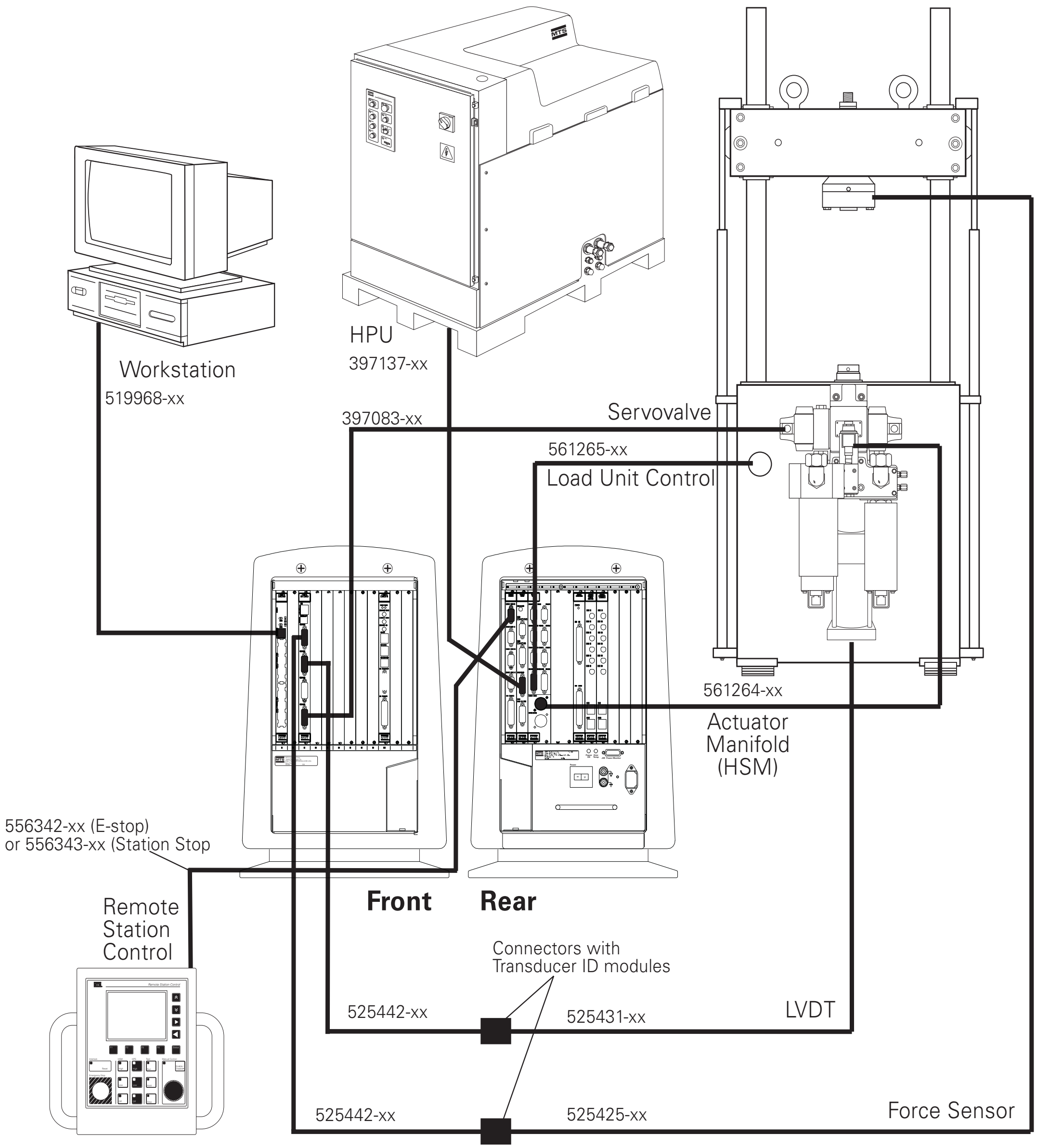
Low-frequency ground loops

It is possible that grounding both ends of the overall shield can produce a low frequency ground loop current. If you experience an unacceptable low-frequency noise level, try the following in the order given:

- Connect the system (chassis) ground of the external device directly to the controller chassis.
- Disconnect the overall shield from the metallized back shell at the external device and add a capacitor (approximately 0.01 µf) to one end of the cable between the shield and the metallized backshell.
- Disconnect the overall shield from the metallized back shell at the external device.

Typical Cabling

Other cables are available, see “Cable Part Numbers” on page 43.



Cable Part Numbers

System cables

The following is a list of the most common cables, see the System Cable/Jumper Plug 493 Package Selection drawing (MTS part number 700-000-656) for the most current and additional cable part numbers.

Cable Description	Part Number*	Module Connector	Jumper Plug†
Servovalve 252.xx single	397083-XX	493.40 J4–J7	N/A
Servovalve 252.xx dual	397084-XX	493.40 J4–J7	N/A
Servovalve 256.xx 3-stage			N/A
Valve	554396-XX	493.40 J4–J7	
Valve LVDT	397086-XX	493.40 J4–J7	
Calibration Cable Package	100-026--213	493.40 J3	
Y Adapter—Servovalve/Valve LVDT (required for 256.xx or 257.xx servovalves)	397105-01	493.40 J4–J7	N/A
Servovalve 257.xx 3-stage			N/A
Valve	397019-XX		
448.16 to 257.XX	397002-XX	493.40 J4–J7	
Valve Velocity	397009-XX	493.40 J4–J7	
Valve LVDT	397086-XX	493.40 J3	
Calibration Cable Package	100-026--213		N/A
		493.40 J4–J7	
Y Adapter—Servovalve/Valve LVDT (required for 256.xx or 257.xx servovalves)	397105-01		
System ground (console)	054023-XX		N/A
System ground (floor standing)	397092-XX	gnd lug	
E-stop 318 Load Unit w/crosshead locks	561265-XX	493.74 J29	100-007-947
E-stop 318 Load Unit wo/crosshead locks	561266-XX	493.74 J29	100-007-947
Emergency Stop		493.73 J24	397132-01
HPU 505 or 24V PLC Pump (see "Hydraulic Configurations" on page 259 for more information)	397137-XX	493.73 J25	397133-01
HSM 298.11 on/off	397015-XX	493.74 J28	N/A
HSM Proportional 298.12	561264-XX		
HSM 290.xx/293.xx/294.xx high/low	397014-XX		
Interlock—Test Enclosure	561263-XX	493.74 J43	100-007-948
Interlock—Station	per system	493.74 J43	100-007-948

CABLE DESCRIPTION	PART NUMBER*	MODULE CONNECTOR	JUMPER PLUG†
Remote Station Control—with E-Stop	556342-XX	493.71 J50	556341-01
Remote Station Control—with Station Stop	556343-XX	493.71 J50	556341-01
Workstation Link (Ethernet cable)	519968-XX	10/100‡	N/A
Remote Setpoint Adjust Control	100-051-058	493.40 J4–J7	N/A

* -XX specifies cable length. –01 through –09 represent 10–50 ft. in 5 ft. increments. Higher numbers represent custom cable lengths.

† Jumper plugs are required if a cable is not installed.

‡ The connector is the 10/100 BaseT connector on the power PC module.

Sensor cables

See “Sensor Cables” on page 133 for sensor cable part numbers. Sensor cables both with and without ID modules are described. Also see the System Cable/Jumper Plug 493 Package Selection drawing (PN 700-000-656) for the most current part numbers.

I/O Carrier Connections

Each Model 493.40 I/O Carrier module can include up to four daughter boards. Each installed daughter board is assigned a specific I/O Carrier module front panel connector (**J4–J7 I/O**).

A hardware interface file (.hwi) defines each type of module (and their associated daughter boards) and maps each module location for the system software. The .hwi file and the physical locations for each type of module and associated daughter boards must match. Also, the I/O Carrier module address setting (on the module) must match the .hwi file address. For more information on the .hwi file, see "The .HWI File" on page 283

- Transducer connections require a conditioner daughter board be installed in the I/O Carrier module. The following conditioners can be installed:
  - Model 493.21B Digital Universal Conditioner
  - Model 493.25 Digital Universal Conditioner
  - Model 493.47 Encoder
  - Model 493.48 Acceleration Conditioner

  See "Transducer Connections" on page 127 for more details.
- Valve connections require a valve driver daughter board be installed in the I/O Carrier module. The following valve drivers can be installed:
  - Model 493.14 Valve Driver
  - Model 493.15 3-Stage Valve Driver
- Analog I/O connections require an A/D or D/A daughter board be installed in the I/O Carrier module. The following analog daughter boards can be installed:
  - Model 493.45 A/D Converter
  - Model 493.46 D/A Converter

Valve Connections

The following types of valve connections are supported:

- Single or dual Series 252 Servovalve(s) can be controlled with a Model 493.14 Valve Driver daughter board.
- A Series 256 Servovalve can be controlled with a Model 493.15 3 Stage Valve Driver daughter board.
- A Series 257 Servovalve can be controlled with a Model 493.15 3 Stage Valve Driver daughter board and a Model 448.16C Power Driver chassis.

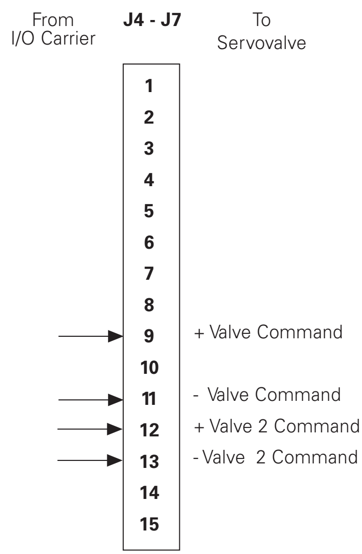
Cable specification

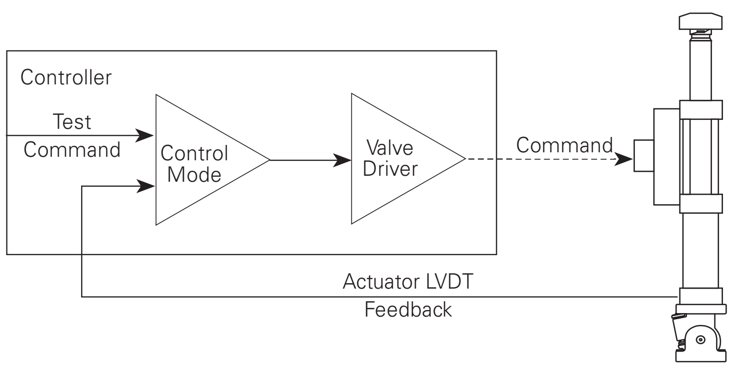
- 15 contact type D male EMI connector
- Backshell–EMI metallized plastic
- Cable type–4 conductor w/foil shield and drain (100935-80 or equivalent) with the drain wire connected to metallized plastic backshell at the chassis.
- For 256 and 257 servovalves, the valve LVDT uses the same type of connectors as the actuator LVDT.
- Servovalve/valve LVDT Y cable required for 256.xx or 257.xx servovalves (397105-XX)

252 servovalve connections

The Series 252 Servovalve is a 2-stage servovalve. The Model 493.14 Valve Driver supports single or dual valve configurations. The following figure shows the connections at the valve driver and the connections between the valve and the valve driver. See "Cable Part Numbers" on page 43 to connect the valve to the I/O Carrier module. See also the servovalve manual for single and dual valve configuration wiring information.

Model 493.14 Valve Driver

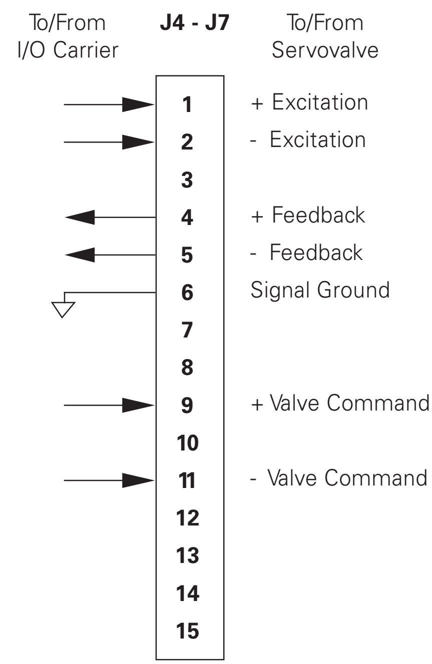


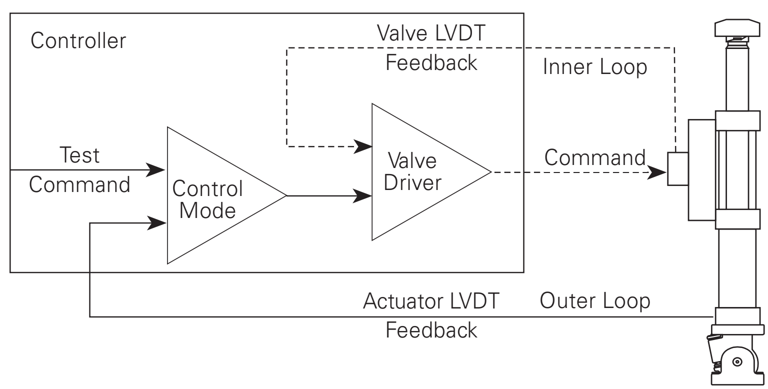


256 servovalve connections

The Series 256 Servovalve is a 3-stage servovalve. The Model 493.15 Valve Driver supports the inner loop signals. The following figure shows the connections between the valve driver and the valve. See "Cable Part Numbers" on page 43 to connect the valve to the I/O Carrier module. See also the servovalve manual for single and dual valve configuration wiring information.

Model 493.15 Valve Driver

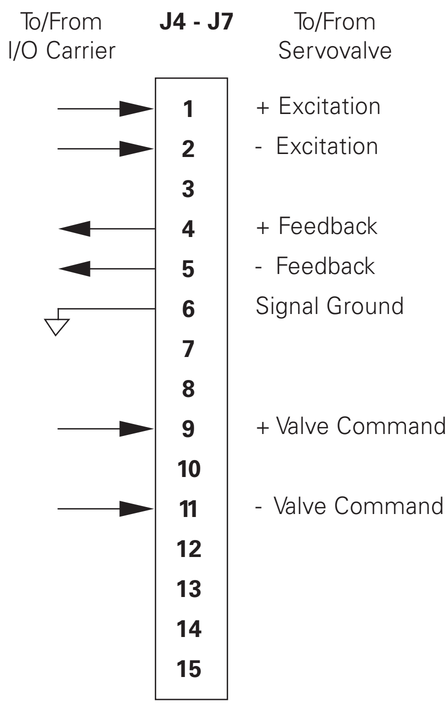


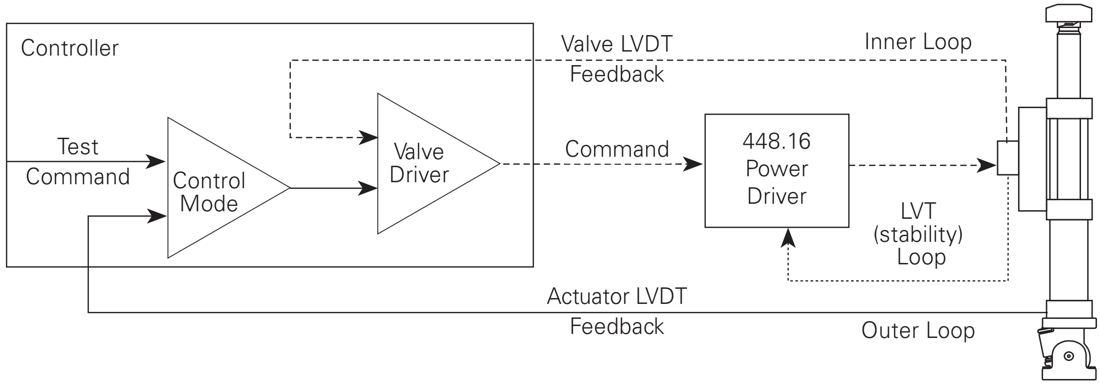


257 valve connections

The Series 257 Servovalve is a 3-stage servovalve that requires a power driver. The Model 493.15 Valve Driver supports the inner loop signals. The following figure shows the connections between the valve driver and the valve. See “Cable Part Numbers” on page 43 to connect the valve to the I/O Carrier module. See also the servovalve manual for single and dual valve configuration wiring information

Model 493.15 Valve Driver

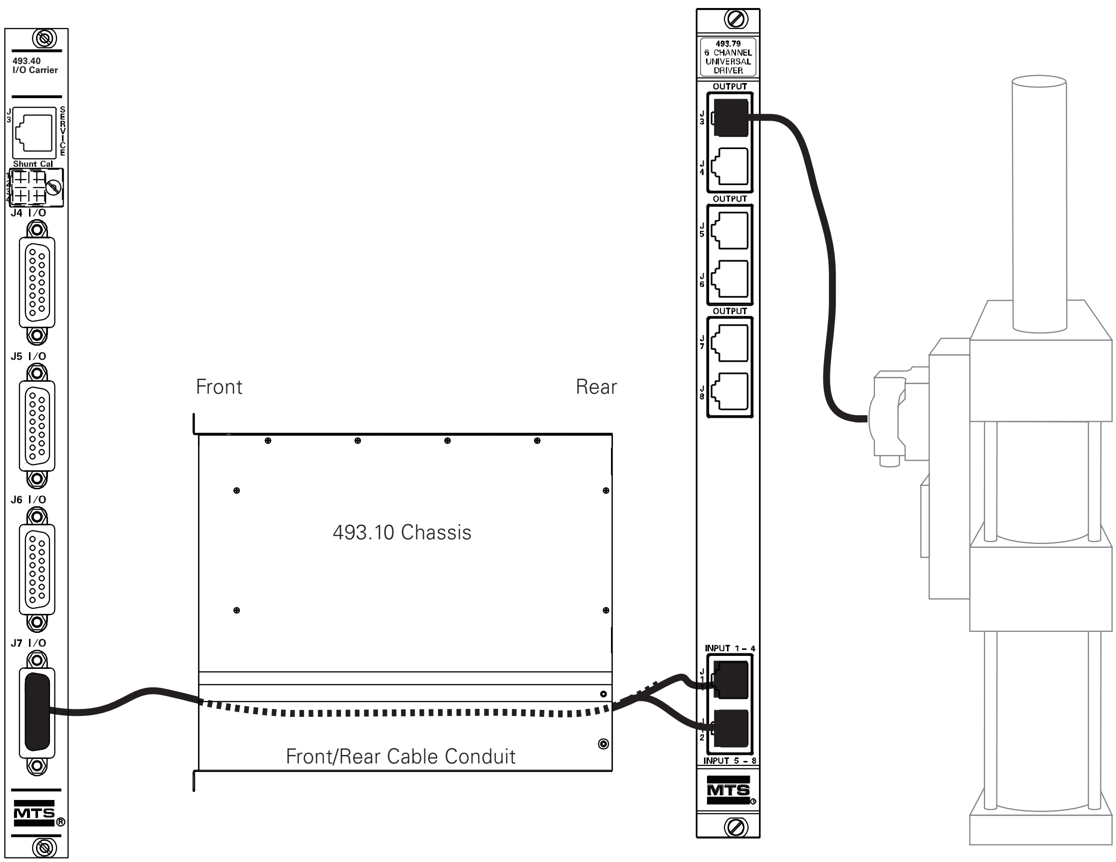




Multiple Universal Driver Connections

For special applications, the Model 493.79 Multiple Universal Driver (MUD) board provides up to six drivers that can be used to drive standard 252 servovalves. Inputs to this board originate from a Model 493.46 D/A board on a Model 493.40 I/O Carrier Module.

A Y-cable (PN 100116173) connects the I/O Carrier module (15 pin, D-Type) to J9/J10 on a MUD board (RJ45).

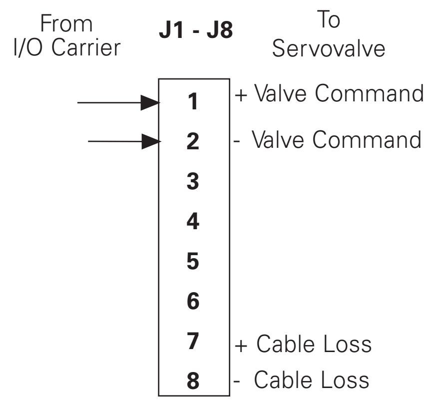


.HWI file definition

See “Multiple Universal Driver” on page 300 for detailed information on the .hwi file definition for a MUD board.

Output connections

Each valve driver output is an RJ45 connection that contains two valve drive output lines and a cable loss detection loop.



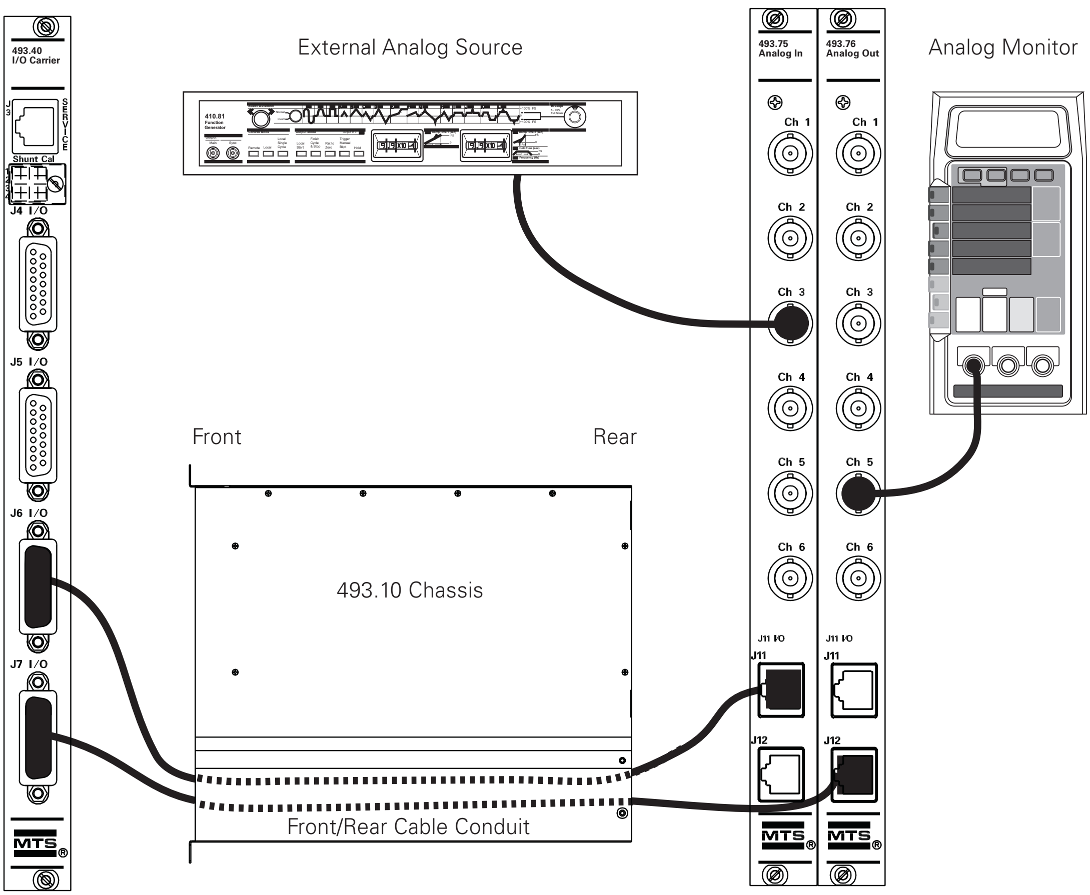
Cable loss detection

The cable loss detection wire loops out to the servovalve and back to the driver output allowing MUD board logic to detect a cable break or a cable disconnect at the MUD board output. A cable loss will not be detected if the cable is disconnected at the servovalve.

Analog I/O Connections

The Model 493.45 A/D and Model 493.46 D/A daughter boards are installed in the Model 493.40 I/O Carrier front panel module. A connection from the front panel daughter board connector to a rear panel BNC transition module allows easy access to the analog channels.

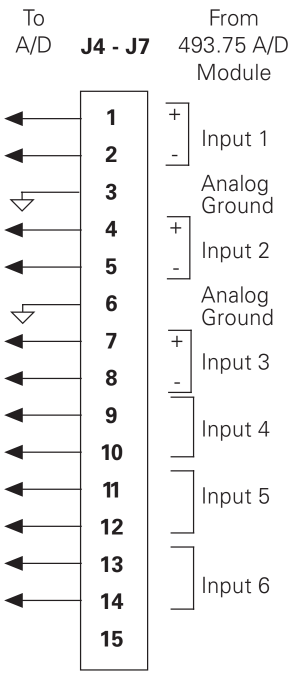
Note *The external analog source can be a stand alone function generator, another controller, or a computer controlled analog output.*



Analog inputs

The analog-to-digital daughter cards accommodate up to six analog input signals. Each A/D input signal must be within ±10 volts.

- Use pin 3 or 6 to prevent problems with floating grounds between devices.
- Analog inputs can be connected at the BNC connectors of a Model 493.75 Analog In transition module and the outputs from this module are connected to the Model 493.40 I/O Carrier module.
- Analog inputs can be connected at the BNC connectors of a Model 493.77 Filtered Analog Input transition module and the outputs from this module are connected to the Model 493.40 I/O Carrier module.



493.77 filter modules

The following filter modules are available for board mounting at the BNC connectors of a Model 493.77 Filtered Analog Input transition module:

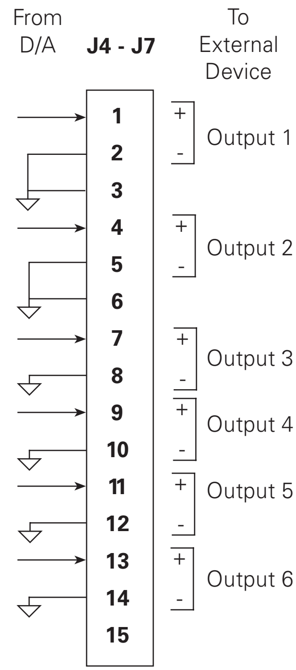
Assembly Number	HZ	Type
477744-01	50	Bessel
477744-02	100	Bessel
477744-03	200	Bessel
477744-04	500	Bessel
477744-05	1000	Bessel
477744-06	2000	Bessel
477744-07	5000	Bessel
477744-08	120	Bessel
477744-09	300	Bessel

Cabling

D/A Connections

Digital-to-analog daughter cards support up to six program or readout signals to external devices. Each D/A signal is an analog output within ±10 volts.

- Each readout signal is from a 16 bit digital to analog converter.
- Each output is a ±10 V analog output.
- The Model 493.46 D/A daughter card provides analog signals to the Model 493.76 Analog Out transition module. Analog outputs are available at the BNC connectors of a Model 493.76 Analog Out transition module for external devices (DVM, oscilloscope).



Cable specification

The cable specifications apply to both the analog inputs and analog outputs.

The cable from the front panel of the I/O Carrier module has the following specification:

- 15 contact type D male EMI connector.
- Backshell–EMI metallized plastic.
- Cable type–up to 6 shielded twisted pairs, each with the drain wire connected to the signal source.

The cable to the **Ch 1 - Ch 6** connectors on the rear panel have the following specifications:

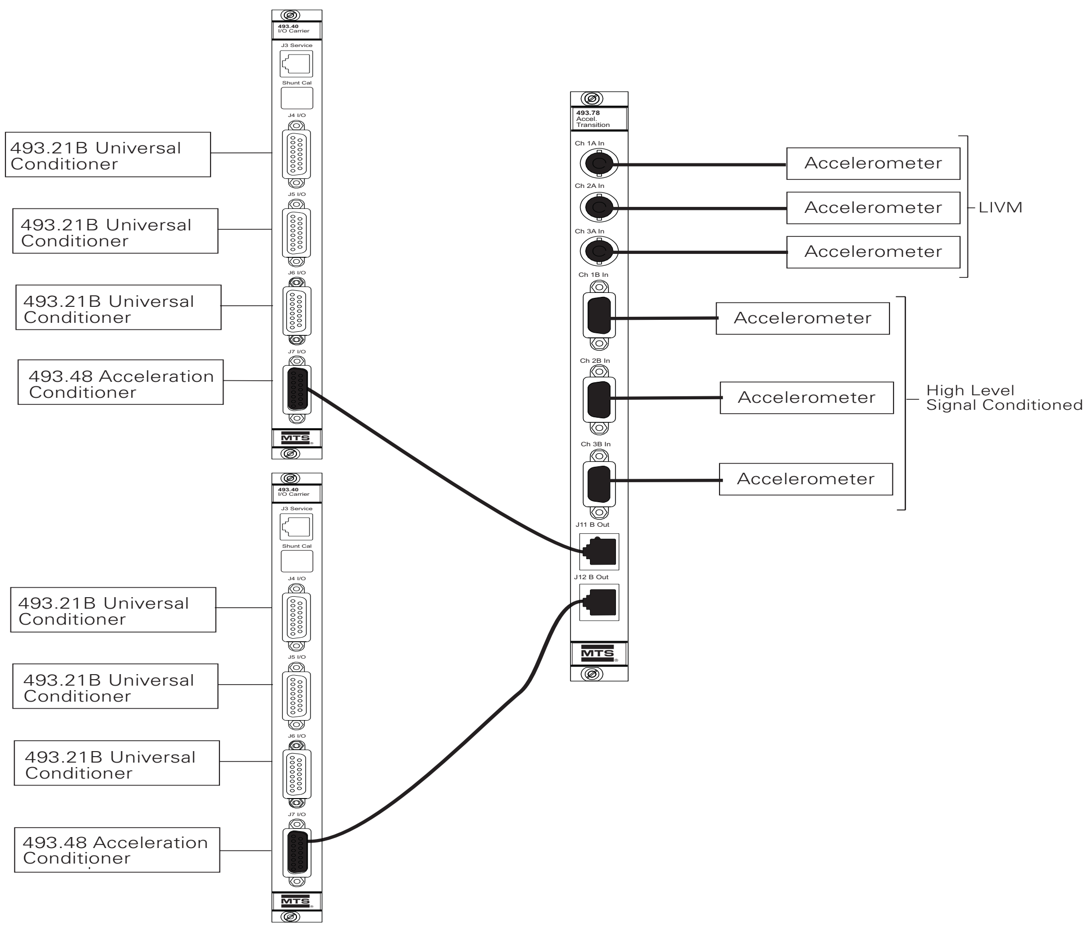
- BNC connector UG88/U
- Cable–RG-58 coaxial
- Use of a smaller coaxial cable and a RG-174 BNC connector with an appropriate cable end is permissible.

Cabling

Accelerometer Connections

An accelerometer requires the Model 493.48 Acceleration daughter board (installed in a Model 493.40 I/O Carrier module) and the Model 493.78 Accelerometer Transition Board.

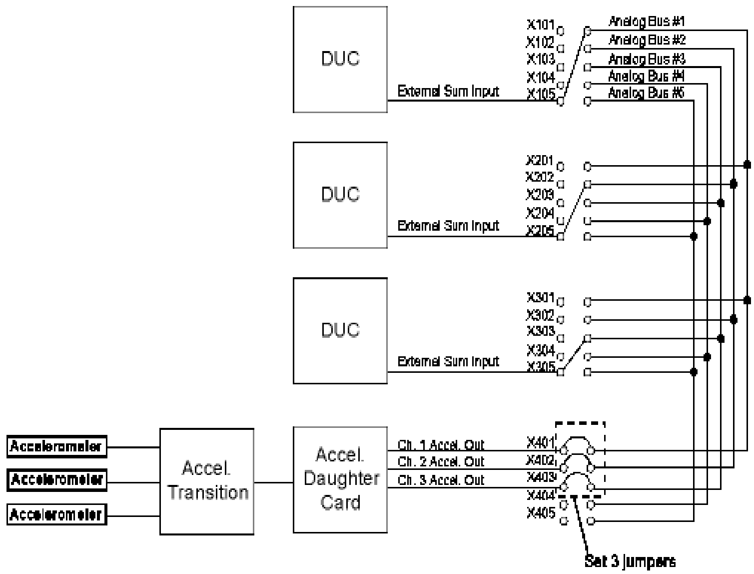
- Each Model 493.48 Acceleration daughter board supports up to three accelerometers.
- The transition board accommodates two types of accelerometers: Low impedance Voltage Mode (LIVM) type accelerometers and High Level Signal Conditioned type accelerometers.



I/O Carrier jumper settings

Before installing a Model 493.48 Acceleration Conditioner daughter board in a Model 493.40 I/O Carrier module, specific jumpers must be set. Jumper settings depend on the number and configuration of your system accelerometers.

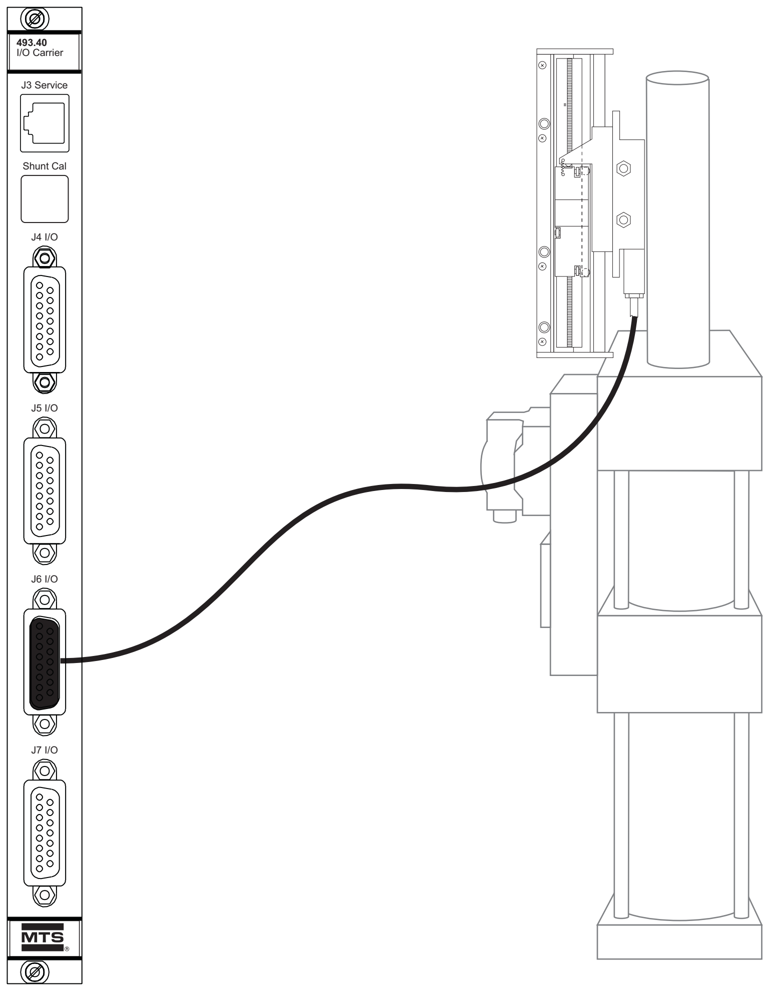
In the example shown below, the Acceleration Conditioner supports three accelerometers. The indicated three jumpers must be set on the I/O Carrier module



Encoder Connections

I/O Carrier Module Configuration

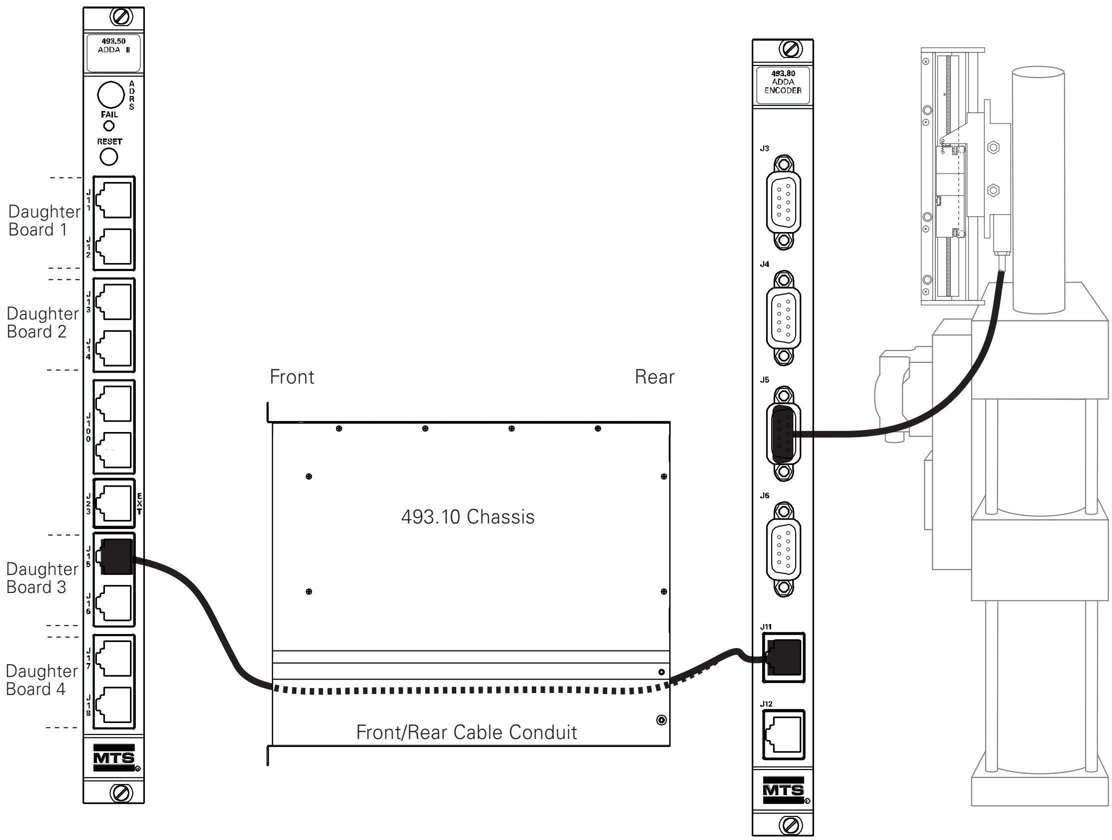
For an ADDA configuration using an I/O Carrier module, each encoder requires installation of a Model 493.47 Encoder Interface daughter board on the Model 493.40 I/O Carrier board. The I/O Carrier connector is based on the location of the daughter board installed on the board of the I/O Carrier module. See "Determine installed location" on page 204



Optional ADDA II Configuration

For the optional ADDA II configuration (using the Model 493.50 ADDA II module), each encoder requires installation of a Model 493.59 Universal Encoder daughter board on the Model 493.50 ADDA II module.

The Model 493.80 Encoder Transition module provides up to four channels of encoder interface between the Model 493.50 ADDA II module and various incremental, Temposonics, or other digital and serial data tranducers.



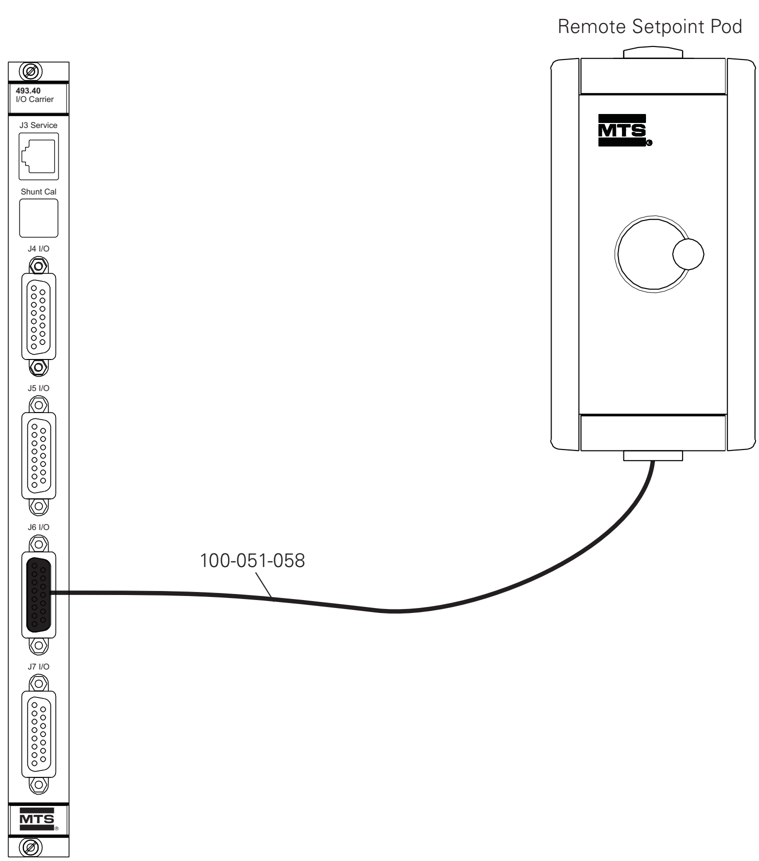
Cabling

Remote Setpoint Adjust Connections

A Remote Setpoint Adjust (RSA) control is an optional, stand-alone hardware device that uses an incremental or absolute encoder to control actuator setpoints.

Each RSA control pod requires installation of a Model 493.47 Encoder Interface daughter board on the Model 493.40 I/O Carrier board. The I/O Carrier connector is based on the location of the daughter board installed on the board of the I/O Carrier module. See “Determine installed location” on page 204.

See “Setting Up Remote Setpoint Adjust” in the Station Builder chapter of the 793.00 Software manual for more information on configuring your system for RSA use.



ADDA II Connections

Each optional Model 493.50 ADDA II module supports up to four daughter boards. Each installed daughter board is assigned a specific ADDA II module front panel connector (**J11–J18**).

A hardware interface file (.hwi) defines each type of module (and their associated daughter boards) and maps each module location for the system software. The .hwi file and the physical locations for each type of module and associated daughter boards must match. Also, the ADDA II module address setting (on the module) must match the .hwi file address. For more information on the .hwi file, see "The .HWI File" on page 283

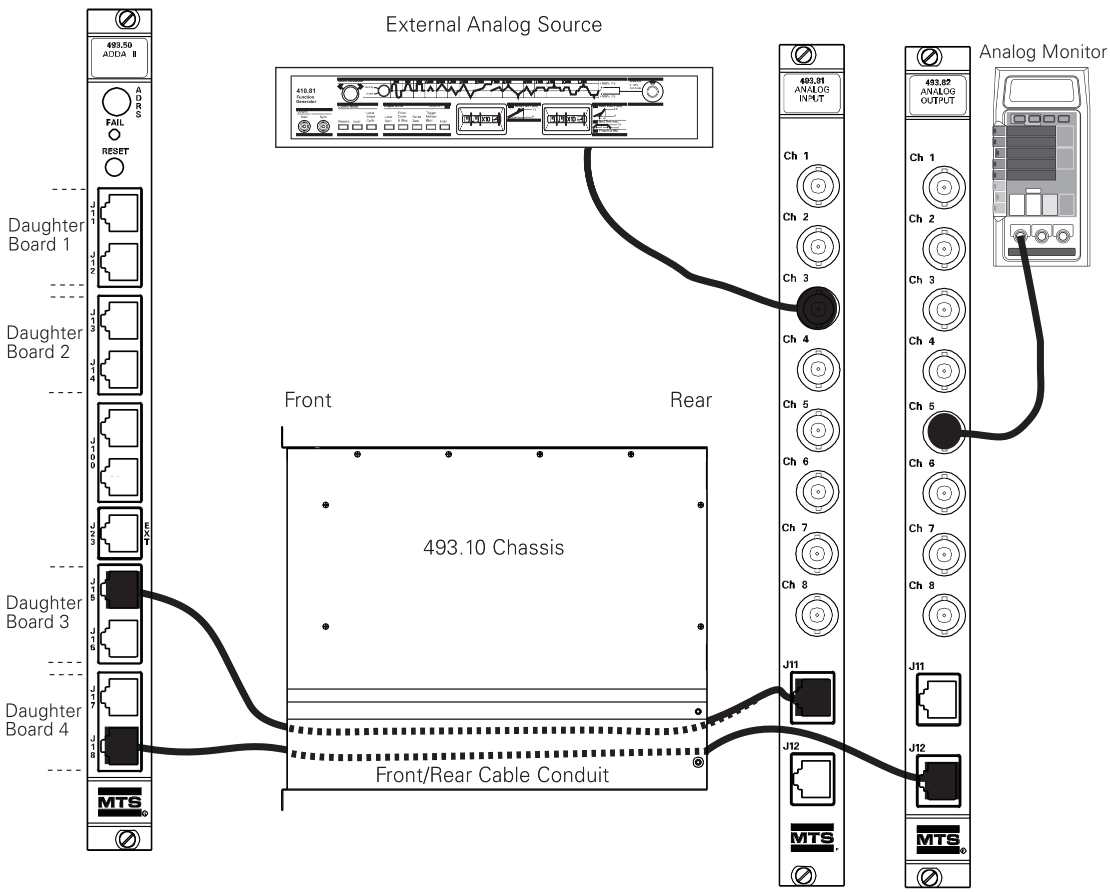
The following A/D or D/A daughter boards can be installed:

- Model 493.55 A/D
- Model 493.56 D/A
- Model 493.57 DSPAD
- Model 493.59 Universal Encoder

ADDA II Module I/O Connections

The Model 493.55 A/D, Model 493.57 DSPAD, and Model 493.56 D/A daughter boards are installed in the Model 493.50 ADD II module assembly. A connection from the front panel connector to a rear panel BNC transition module allows easy access to the analog channels.

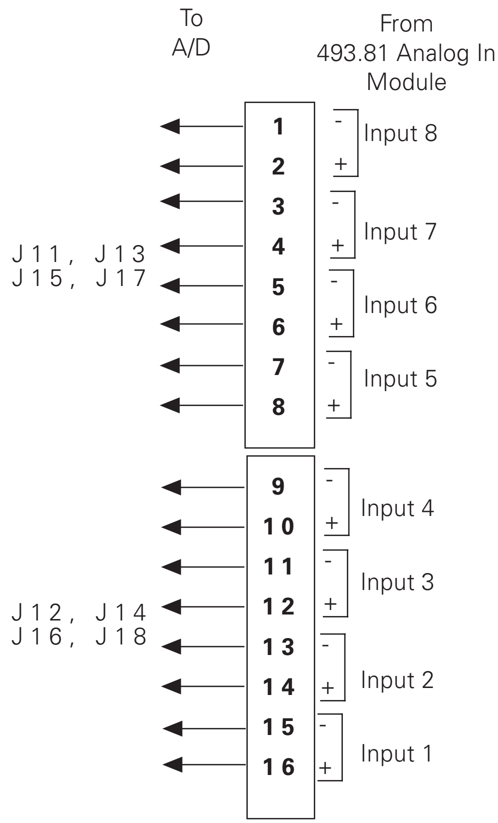
Note *The external analog source can be a stand alone function generator, another controller, or a computer controlled analog output.*



Analog inputs

The analog-to-digital daughter cards accommodate up to eight analog input signals. Each A/D input signal must be within ±10 volts.

- Analog inputs can be connected at the BNC connectors of a Model 493.81 Analog In transition module and the outputs from this module are connected to the Model 493.50 ADDA II module.
- Analog inputs can be connected at the BNC connectors of a Model 493.83 Filtered Analog Input transition module and the outputs from this module are connected to the Model 493.50 ADDA II module.



D/A Connections

Digital-to-analog daughter cards support up to eight program or readout signals to external devices. Each D/A signal is an analog output within ±10 volts.

- Each readout signal is from a 16 bit digital to analog converter.
- Each output is a ±10 V analog output.
- The Model 493.56 D/A daughter card provides analog signals to the Model 493.82 Analog Out transition module. Analog outputs are available at the BNC connectors of a Model 493.82 Analog Out transition module for external devices (DVM, oscilloscope)

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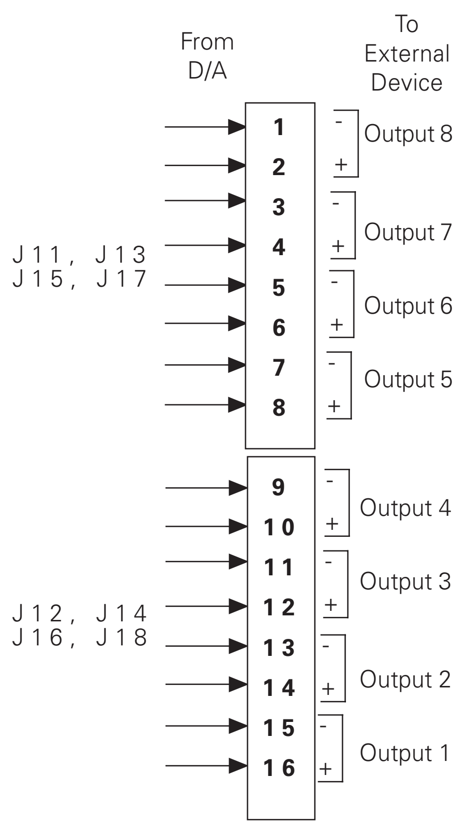
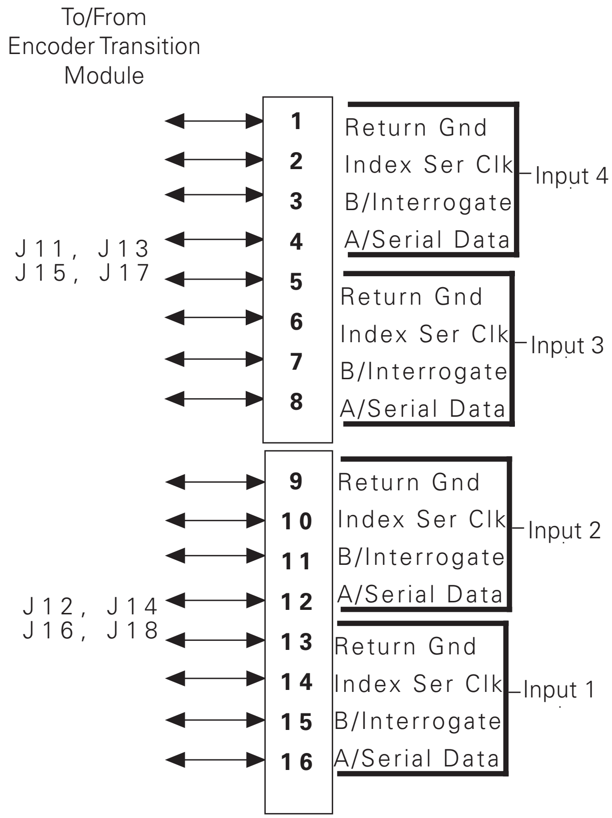


ADDA II Universal Encoder Connections

Each encoder requires a Model 493.59 Universal Encoder daughter installed on the Model 493.50 ADDA II module.

Up to four encoders can be connected to the Model 493.80 ADDA II Encoder Transition module when the Model 493.50 ADDA II module is fully populated with Universal Encoder cards.

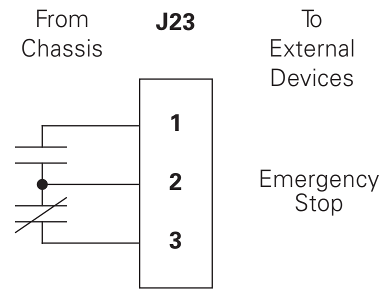


Emergency Stop Connections

Connectors **J23 E-STOP Out** and **J24 E-STOP In** are located on the Model 493.73 HPU transition board. The emergency stop switch and signal are part of a controller-wide interlock system.

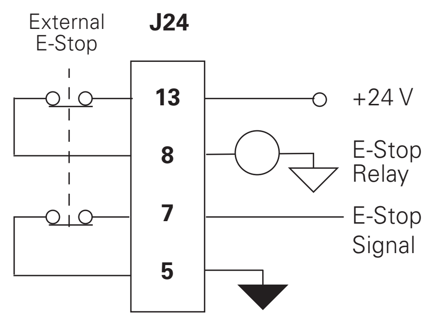
Emergency stop output

Connector **J23 E-STOP Out** provides an output to external devices when an emergency stop signal is generated. The inactive status is shown in the figure.



Emergency stop input

Connector **J24 E-STOP In** accommodates an external emergency stop switch. As shown, several connectors maintain the continuity of the emergency stop interlock.



Cable specifications

J23 E-STOP Out is a 9 pin type D male connector

- 9 contact type D female EMI connector
- Cable—24 AWG, 10 conductor with overall foil shield, (Carol C0745 or equivalent) with drain wire connected to metallized plastic backshell to the chassis.

J24 E-STOP In is a 15 pin type D female connector.

- 15 contact type D male EMI connector.
- Backshell–EMI metallized plastic.

- Cable–24 AWG 4 connector with overall foil shield, (Belden 9534 or equivalent) with drain wire connected to metallized plastic backshell at the chassis and to ground at the emergency stop station.

Jumper plug required

If connector **J24** is not used, you must install a jumper plug to maintain the integrity of the interlocks. Use jumper plug 397132-01 or jumper pins: 5 and 7; 8 and 13.

Hydraulic Power Unit Connection

Connector **J25 HPS** on the Model 493.73 HPU transition board controls the hydraulic power unit (HPU).

- The module produces 24 V logic signals to control the HPU.
- The Model 493.07 HPU Converter Box allows any MTS HPU to be connected to the chassis with the following exceptions:
  - 506.52-.92 HPUs (24 volt, PLC compatible)
  - All Series 505 HPUs

  The converter box is used with other configurations, see “Hydraulic Configurations” on page 259 for more information.

CAUTION

Control voltages for hydraulic power units vary between models.

The HPU interface between the Model 493.73 HPU transition board and an HPU is 24 volt logic signals. Connecting J25 to a non-compliant HPU can damage the module.

DO NOT connect 24 V DC relay circuitry or 115 V AC circuitry to the HPU connector J25.

Service LED

The Service LED turns on when electrical power is applied and it turns off when the chassis makes contact with the personal computer.

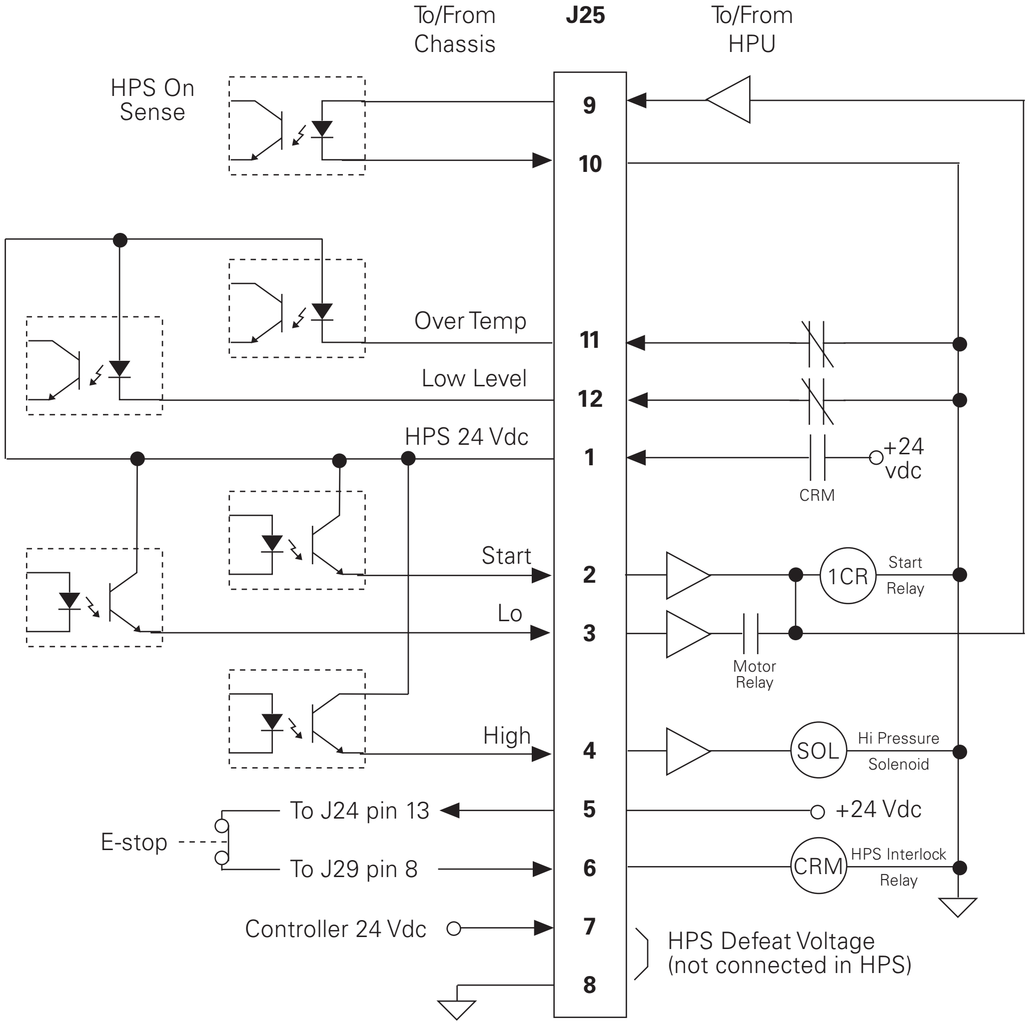
Cable specification

J25 HPS is a 15 pin type D male connector.

- 15 contact type D female EMI connector.
- Cable—24 AWG, 10 conductor with overall foil shield, (Carol C0745 or equivalent) with drain wire connected to metallized plastic backshell to the chassis.

Jumper plug required

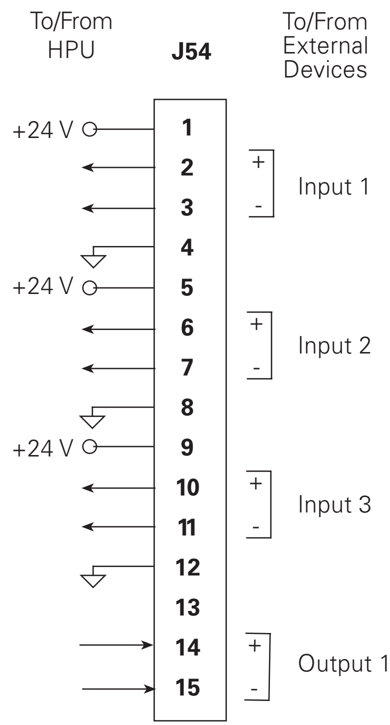
If connector **J25 HPS** is not used, you must install a jumper plug to maintain the integrity of the interlocks. Use jumper plug 397133-01 or jumper pins: 1–7, 2–3–5, 6–9, 8–10–11–12.



To/From Chassis
J25
To/From HPU
HPS On Sense
9
10
Over Temp
11
Low Level
12
HPS 24 Vdc
1
+24 vdc
CRM
Start
2
1CR
Start Relay
Lo
3
Motor Relay
High
4
SOL
Hi Pressure Solenoid
E-stop
To J24 pin 13
5
+24 Vdc
To J29 pin 8
6
CRM
HPS Interlock Relay
Controller 24 Vdc
7
8
HPS Defeat Voltage (not connected in HPS)

System I/O

Connector **J54 Sys I/O** provides three digital inputs and one digital output. The inputs are connected to the high and low inputs of an opto-isolator. The out is from the collector (+) and emitter (-) of an opto-isolator. See the “Digital I/O Connections” on page 79 for circuit drawings.



Cable specification

J54 Sys I/O is a 15 contact type D female connector.

- 15 contact type D male EMI connector.
- Backshell–EMI metallized plastic.
- Cable–24 AWG 4 connector with overall foil shield, (Belden 9534 or equivalent) with drain wire connected to metallized plastic backshell at the chassis and to ground at the emergency stop station.

Station Connections

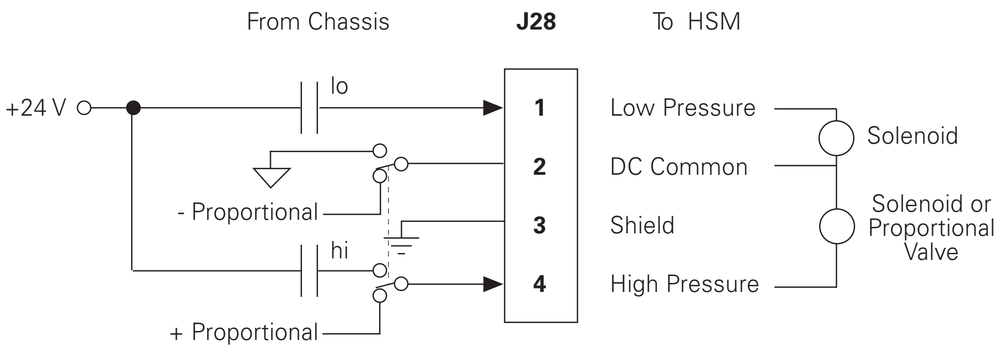
Each Model 493.74 HSM transition board controls up to two stations. A standard chassis configuration supports up to four stations. Each station has the following connections

- J28 Hydraulic service manifold (HSM)
- J29 Load unit
- J43 Interlock
- J44 Remote run/stop
- J49 Auxiliary power

As a system option, the 493.10 chassis can be configured to support for six or eight stations. See "Optional Station Configurations" on page 267.

J28 HSM

Connector **J28 HSM** controls the pressure of a hydraulic service manifold. The controller software can configure the connector for solenoid or proportional control of a 24 volt hydraulic service manifold.



Cable specification

- P28 is a 4-contact CPC male connector (AMP Incorporated).
- Cable for on/off HSMs–18 AWG/2 conductor with overall foil shield (Carol C2534 or equivalent) with drain wire connected to pin 3 at the chassis.
- Cable for high/low HSMs–18 AWG/4 conductor with overall foil shield (Carol C2543 or equivalent) with drain wire connected to pin 3 at the chassis.

Proportional output

The proportional output is configured with the controller software.

- The output signal can be ramped from 20 mA (minimum) to 700 mA (maximum) which corresponds with 50 psi (0.4 MPa) and 3000 psi (21 MPa). By default, low pressure is factory set at 750 psi and high pressure is set at 3000 psi.
- The ramp rate from zero to high pressure can be set to two or four seconds. The ramp rate from high pressure to zero can be set to zero, two or four seconds.
- The ramp rate is constant (set to the two or four second rate), The amount of time to reach low pressure depends on the low pressure setting.

.hwi file settings

The following items can be specified in the .hwi file. For more information, see “Hydraulic Control” on page 286.

- HSM ramp rate from zero to high pressure (**HSM RATE**):

  SLOW = zero to high pressure in approximately 4 seconds
  FAST = zero to high pressure in approximately 2 seconds

- HSM high pressure to zero mode (**HSM OFF MODE**):

  STEP = HSM steps from high pressure to zero (default)
  RAMP = HSM ramps from high pressure to zero

Important *Unless there is a special need, **HSM OFF MODE** should not be set to **RAMP**. For your safety, keep this setting at **STEP**.*

- HSM low pressure setting as a percentage of full-scale (**LOW PERCENT**)
- HSM high pressure setting as a percentage of full-scale (**HIGH PERCENT**)
- HSM type can be set to **PROPORTIONAL**, **SOLENOID**, or **ON_OFF_SOLENOID**.

  If you select **ON_OFF_SOLENOID** only 2 HSM control buttons (OFF/ON) will appear on the Station Manager **Station Controls** panel. For the other selections, 3 HSM control buttons will appear (OFF/LOW/HIGH).

J29 Load Unit

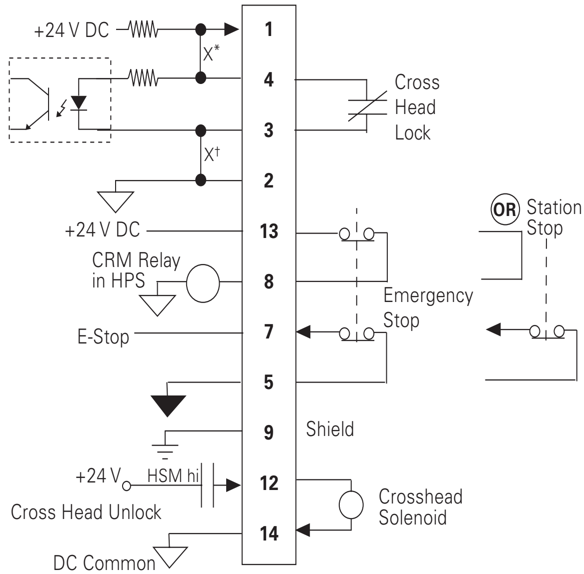
Connector **J29 Load Unit** connects to the load unit lift/lock panel.

Pins 1, 2, 3, and 4 can be configured for contacts (with jumpers X^* and $X^\dagger$) or a logic signal (without jumpers X^* and $X^\dagger$).

X^* = Jumper X2 for Channel A
Jumper X1 for Channel B

$X^\dagger$ = Jumper X4 for Channel A
Jumper X3 for Channel B

Pins 5, 7, 8, and 13 maintain the continuity of the emergency stop interlock.



Cable specification

- P29 is a 15-contact, type D, male, EMI connector.
- Cable for load frames with crosshead locks built after 1985, 18 AWG, 8 conductor with overall foil shield Alpha 5388C or equivalent with drain wire connected to pin 9 at both ends of the cable.
- Cable for all load frames without crosshead locks–22 AWG, 6 conductor with overall foil shield Alpha 5386C or equivalent with drain wire connected to pin 9 at both ends of the cable (pin 9 may be pin E at the load frame).

Jumper plug

If connector **J29** is not used, you must install a jumper plug to maintain the integrity of the interlocks. Use jumper plug 100-007-947 or jumper pins: 3 and 4; 5 and 7; 8 and 13.

Station stop

The Emergency Stop connection can also be configured as a station stop. When this is done, be sure that you have other Emergency Stop boxes near by. Pressing **Station Stop** will shut down the hydraulics to an individual station without shutting down power to the hydraulic power unit.

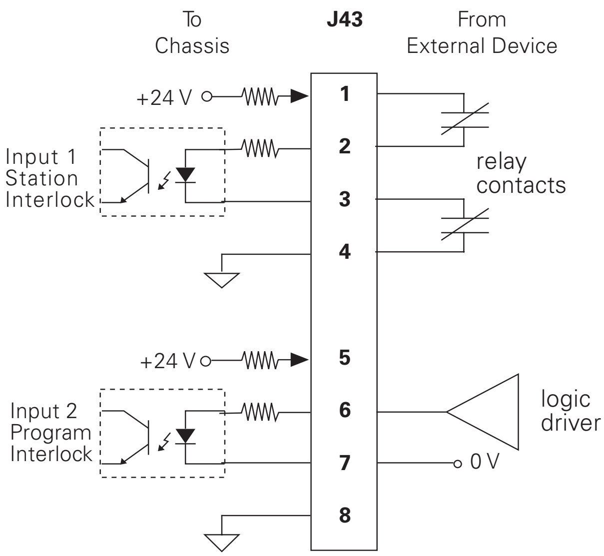
J43 Interlock

Connector **J43 Interlock** accommodates two general purpose inputs to be connected to the interlock chain.

- Input 1 is dedicated as a station interlock.
- Input 2 is dedicated as a program interlock.
- Both inputs are optically isolated.
- If just one contact is used, the other must be jumped.

Both inputs can accept relay contacts or a logic signal. Both configurations are shown.

Each input can be have either configuration.



Cable specification

- 9 contact type D male EMI connector.
- Backshell–EMI metallized plastic.
- Cable–shielded twisted pairs (24 AWG minimum) with drain wire(s) connected to the metallized backshell at the chassis.

Power characteristics

Channel inputs can be 3 volts (minimum) and 26 volts (maximum) from an external voltage source.

Jumper plug

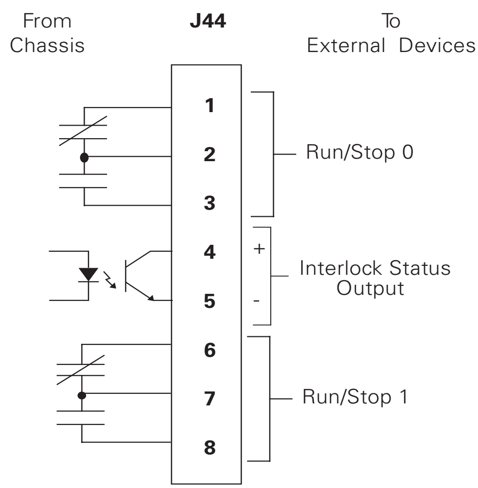
If connector **J43** is not used, you must install a jumper plug to maintain the integrity of the interlocks. Use jumper plug 100-007-948 or jumper pins 1 and 2; 3 and 4; 5 and 6; 7 and 8.

J44 Run/Stop

Run/Stop status

Connector **J44 Run/Stop** provides the run/stop status of the controller to external devices.

- Two form C contacts provide the run/stop status.
- The contacts are rated 1.0 A at 30 V (AC or DC).



Interlock status

Connector **J44 Run/Stop** also provides opto-isolator outputs that indicate the interlock status of each station to an external device. These interlock status outputs are normally on and will turn off when an interlock occurs. See “Digital outputs” on page 81 for detailed circuit drawings.

Output specifications

The specifications for the interlock status opto-isolator outputs are as follows:

- Output Format: open collector, open emitter transistor
- Maximum Voltage: 26 Vdc
- Minimum Guaranteed Output Current Drive: 20 mA (30 mA typical) @ 1.0 V max

Jumper X5

Jumper setting **X5** selects the source for interlock status output. The following jumper settings select the indicated interlock source:

- **X5** Jumpered = HSM Board Interlocks Only
- **X5** Not Jumpered = Station and HPU Interlocks

Jumpers W8/W9

Jumper settings **W8/W9** determine the output polarity of the opto-isolators.

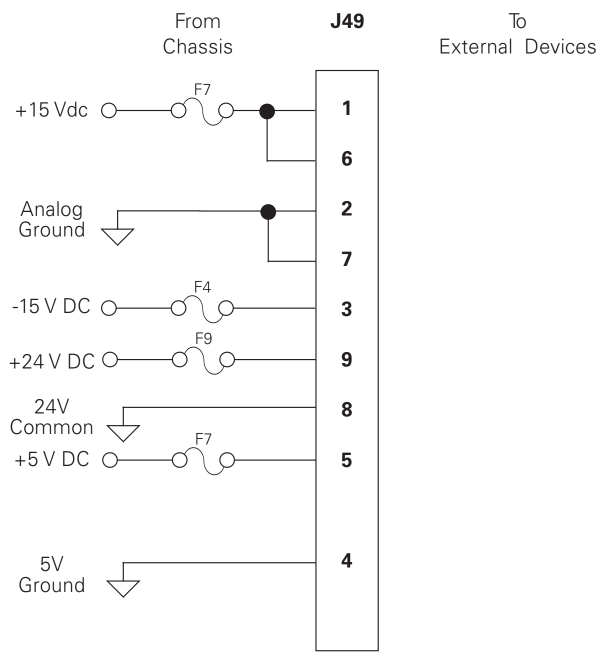
Cable specification

- 9 contact type D female EMI connector
- Backshell–EMI metallized plastic
- Cable–shielded twisted pairs (24 AWG minimum) with drain wire(s) connected to the metallized backshell at the chassis.

J49 Auxiliary Power

Connector **J49 Aux Pwr** provides +5 V DC, ±15 V DC, and 24 V DC from the chassis internal power supply to drive external high level conditioners, proximity switches, solenoids, and so forth.

- The outputs are fused at 0.75 A to protect the power supply from an external short.
- The fuses can be reset by shutting off power and waiting a few minutes (the fuses automatically reset when cooled) then reapplying power.



Cable specification

- 9 contact type D male EMI connector
- Backshell–EMI metallized plastic
- Cable–shielded twisted pairs (22 AWG minimum) with drain wire(s) connected to the metallized backshell at the chassis.

Digital I/O Connections

The Model 493.72 Digital I/O transition module has two connectors; one provides connections for sixteen digital inputs and the other provides connections for sixteen digital outputs.

J3

From External Device	J3	To 493.72 Digital Input
Channel 1 Input	1	+
	20	-
Channel 2 Input	2	+
	21	-
Channel 3 Input	3	+
	22	-
Channel 4 Input	4	+
	23	-
Channel 5 Input	5	+
	24	-
Channel 6 Input	6	+
	25	-
Channel 7 Input	7	+
	26	-
Channel 8 Input	8	+
	27	-
Channel 9 Input	9	+
	28	-
Channel 10 Input	10	+
	29	-
Channel 11 Input	11	+
	30	-
Channel 12 Input	12	+
	31	-
Channel 13 Input	13	+
	32	-
Channel 14 Input	14	+
	33	-
Channel 15 Input	15	+
	34	-
Channel 16 Input	16	+
	35	-
	18	+12 V DC
	19	+12 V DC
	36	
	37	

J4

From 493.72 Digital Output	J4	To External Device
+	1	Channel 1 Output
-	20	
+	2	Channel 2 Output
-	21	
+	3	Channel 3 Output
-	22	
+	4	Channel 4 Output
-	23	
+	5	Channel 5 Output
-	24	
+	6	Channel 6 Output
-	25	
+	7	Channel 7 Output
-	26	
+	8	Channel 8 Output
-	27	
+	9	Channel 9 Output
-	28	
+	10	Channel 10 Output
-	29	
+	11	Channel 11 Output
-	30	
+	12	Channel 12 Output
-	31	
+	13	Channel 13 Output
-	32	
+	14	Channel 14 Output
-	33	
+	15	Channel 15 Output
-	34	
+	16	Channel 16 Output
-	35	
+12 V DC	18	
+12 V DC	19	
	36	
	37	

Digital inputs

The **J3 In** connector accommodates up to sixteen digital signals from external devices. You can use digital input signals to trigger test events with your controller applications.

- All of the inputs are optically isolated and support relay contacts or logic inputs (see the following figure).
- Channel inputs can be 3 volts (minimum) and 26 volts (maximum) from an external voltage source.
- Jumpers select the debounce time for each group of four inputs.

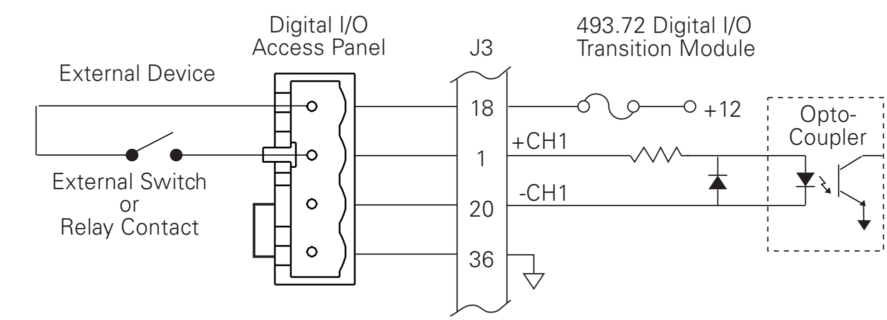
  Jumper X2 configures inputs 1–4.
  Jumper X3 configures inputs 5–8.
  Jumper X4 configures inputs 9–12.
  Jumper X5 configures inputs 13–16.

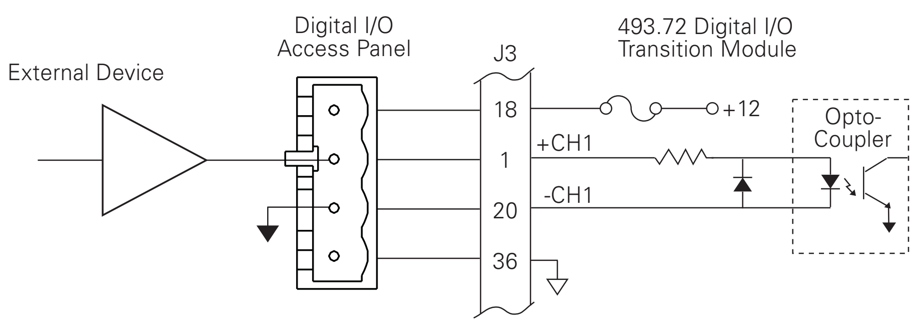
  – No jumper sets the debounce to 20 msec.

  – Jumper pins 1 and 4 to set the debounce to 10 msec.

  – Jumper pins 2 and 3 to set the debounce to 1 msec.

  – Jumper pins 1 and 4, 2 and 3 to set the debounce to 0.1 msec.





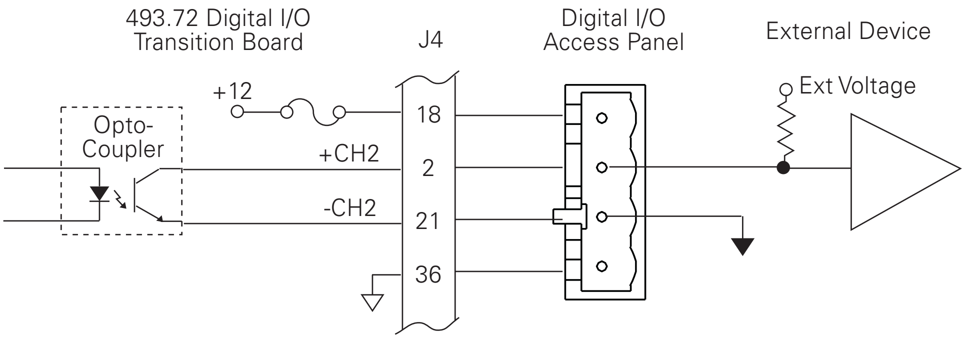
Digital outputs

Connector **J4 Out** provides sixteen general purpose digital outputs that can send digital logic signals to external switches or logic devices.

- Minimum output current drive is 6 mA. Maximum output current drive is 20 mA.

  Note *The maximum output current can vary from unit to unit. The minimum guaranteed output current is 6 mA and the maximum output current is 20 mA. You can connect the digital outputs in parallel to increase the current drive. When connected in parallel, the station must be configured so all paralleled outputs are driven from the same event.*

- The output is rated for a maximum of 30 V DC.
- Fused 12 V DC is available at pins 18 and 19.
- If an output is not used, a jumper is not needed to complete a circuit.
- The outputs are optically isolated.
- The outputs are triggered by the system controller.



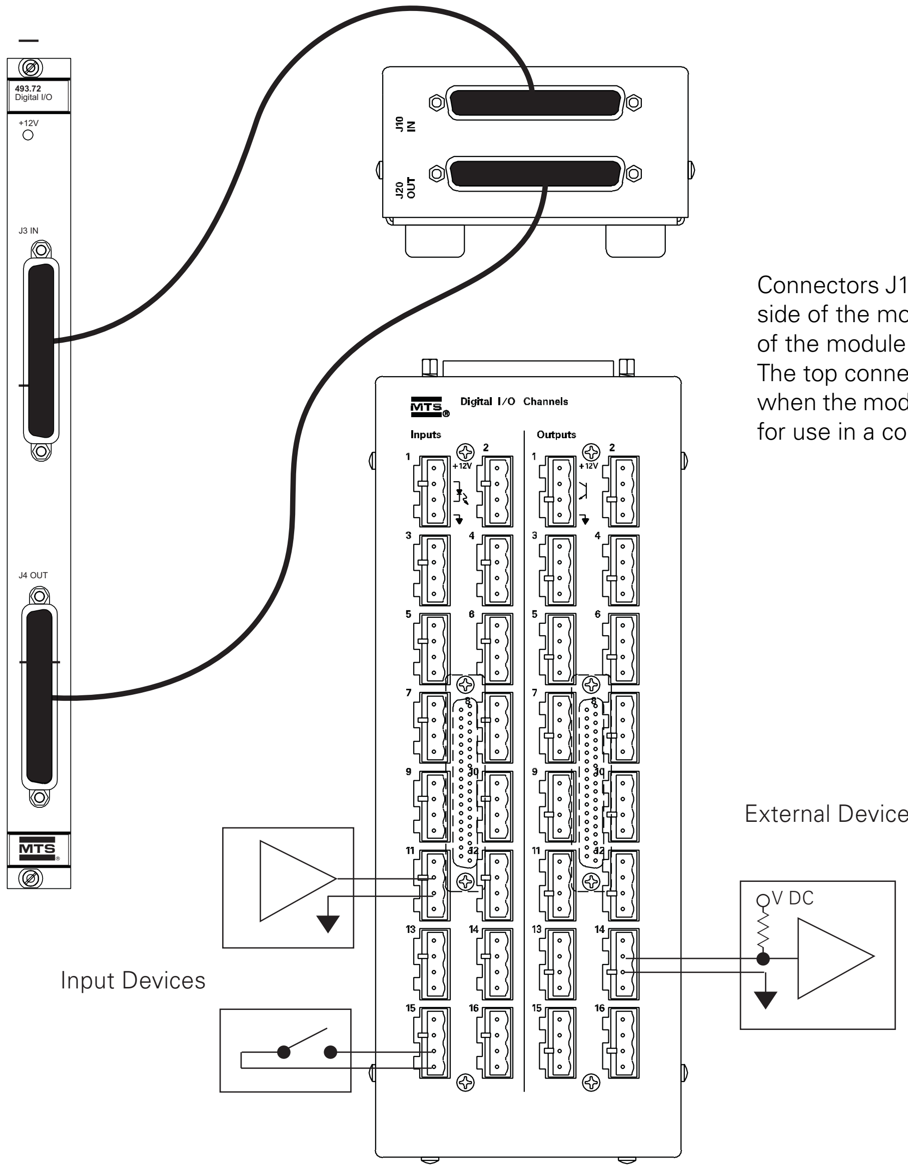
Cable specification

The cabling information shown assumes a single cable destination (with an overall shield). In other applications, the cable may have more than one destination. For these applications an overall shield is not practical and non-EMI connectors and back shells are permissible.

- 37 contact type D male EMI connector
- Back shell–EMI metallized plastic
- Cable–shielded twisted pairs as required (24 AWG minimum) with drain wire(s) connected to the metallized backshell at the chassis.

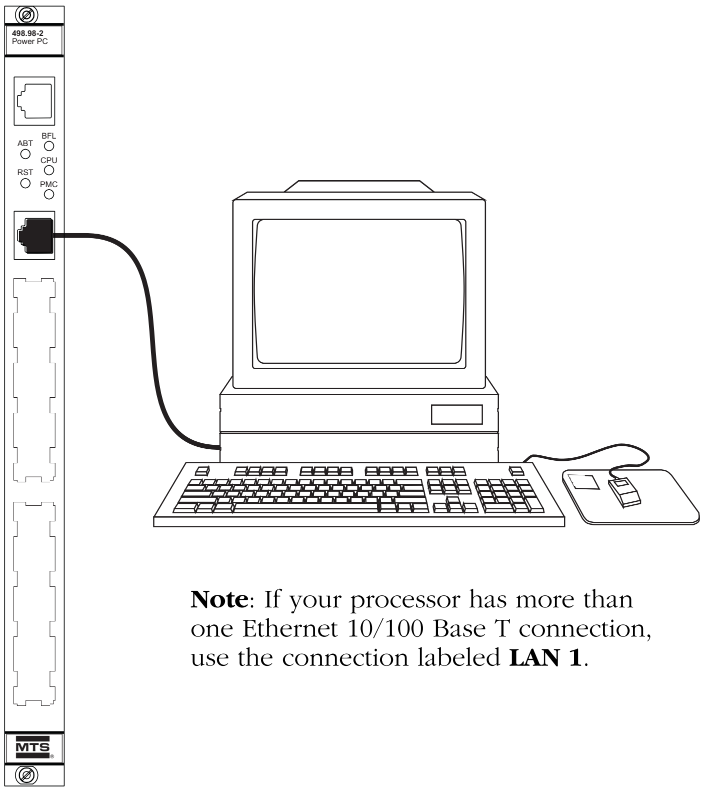
Digital I/O access panel

The digital inputs and outputs can be cabled to an optional digital I/O access box. The box is a convenient way to wire digital sources and destination to the Model 493.72 Digital I/O transition module.



Workstation Connection

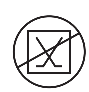
The workstation computer is connected to the Model 498.96 Processor module installed in the VMEbus of the chassis. It is an Ethernet 10/100 Base-T connection. The workstation computer must have an Ethernet compatible connector.



Note: If your processor has more than one Ethernet 10/100 Base T connection, use the connection labeled **LAN 1**.

CAUTION

The symbol shown here indicates that you must not connect telecommunications equipment to the equipment showing this symbol.



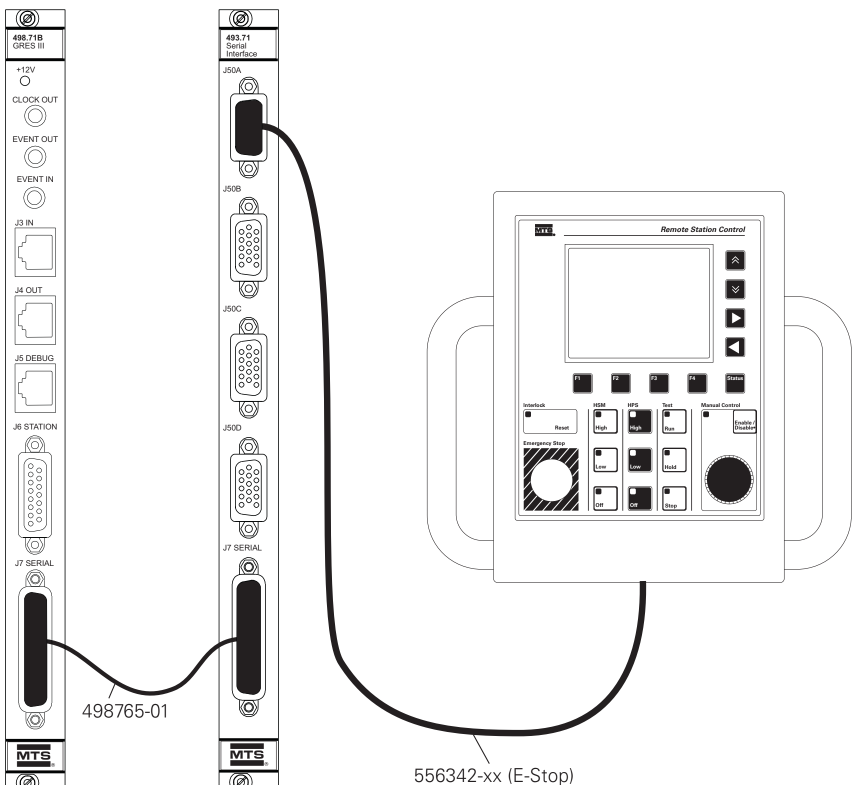
Several modules have connectors that look similar to a phone connector. Special cables are required. Installing telecommunications equipment cables can cause equipment damage to the electrical components of the chassis or to your telecommunications system.

Remote Station Controller Connection

The optional Remote Station Controller (RSC) module requires a Model 498.71B GRES III VMEbus module and a Model 493.71 Serial Interface transition module to be installed in the chassis. The RSC can be connected to any of the four J50 connectors of the serial interface. An interlock is permanently assigned to each J50 connector (e.g., J50A= Interlock 1). Connecting an RSC automatically assigns the RSC pod to the interlock.

The .hwi file defines which connector is used for each station. For more information, see "HWI file additions" on page 85.

The RSC control panel is available in two configurations; one provides an E-Stop and HPS control for single station configurations, and the other provides a Station Stop with no HPS control for multi-station configurations.



HWI file additions

In order to use one or more RSCs with your Model 493.10 Chassis, two sections must be added to your .hwi file, an RSC section and a GRES III section.

Note *Remote Station Controllers are not available with the optional 6 or 8-station system configurations*

Note *If you specified RSC support when you ordered your test system, these sections will be added to your .hwi file at the factory.*

Note *For information on editing your .hwi file to accommodate RSCs, contact MTS.*

The RSC definition is always the same. A GRESIII module is needed to support an RSC in your system. For information on adding a GRES III module, see “GRES III section” on page 85.

RSC section

See “Remote station controller” on page 308 for more information on the RSC section of the .hwi file.

GRES III section

The Model 498.71 GRES III module supports both the Remote Station Controller (RSC) and the Temperature Controller and must be added to your system when using either of these components. See “GRES III” on page 309 for more information on adding a GRES III module to your system.

Service Connections

The Model 493.10 Chassis can have several service connectors. There are two types of connectors:

- The chassis connection monitors the power supply.
- The connection on the I/O Carrier module monitors the output of each daughter board.

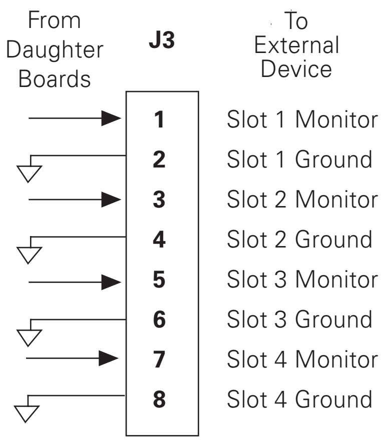
Chassis service

The **J39 Power Monitor** connector is located on the rear panel of the chassis. It functions as test points for a service technician. It allows you to check all of the power supply voltages along with the status of the over-temperature sensor and the power fail circuit.

From Power Supply	J39
+5 Volts	**2**
+12 Volts	**3**
-12 Volts	**4**
+15 Volts	**5**
-15 Volts	**6**
+24 Volts	**7**
Ground	**8**
2.5 Volts Reference	**9**
Ground	**11**
Temperature	**14**
Power Fail	**15**

I/O Carrier service

The **J3 Service** connector on the Model 493.40 I/O Carrier module provides the monitor output from each of the four I/O option cards installed. It is an 8-pin RJ-45 connector.



Important *The signals at the **J3 Service** connector are provided for service and troubleshooting only. These signals are defined by the I/O option daughter boards that are installed on a respective Model 493.40 I/O Carrier module. Some of these signals may be uncalibrated. Before use, take appropriate steps to determine the characteristics of these signals.*

Cabling and Programming External Controllers

This section describes:

- Cabling and programming the Model 493.10/793.00 controller to analog program and feedback signals from a 407 controller.
- Connecting the Model 493.10/793.00 controller to interlock signals from a 407 controller.
- Setting up a 407 controller to send and receive Model 493.10/793.00 controller signals.
- Connecting the Model 493.10/793.00 controller to interlock signals from 458 controllers.

The Model 493.10/793.00 controller supports a special serial connection and software setup for use with Series 2200 and 2400 Eurotherm temperature controllers. For more information, see "Eurotherm Temperature Controller Connection" on page 104.

Important ***When used as programmer, the 793.00 controller does not have automated mode switching capabilities. Control mode selection on the 793.00 controller does not effect the control mode of the controller to which it is sending test commands.***

How to Program an External Controller

To send programming to an external controller, you must:

1. "Cable the controllers." on page 89.
2. "Create your configuration file with Station Builder." on page 92.
3. "Adjust the signals with Station Manager." on page 93.
4. "Set up your program." on page 93.

Task 1 Cable the controllers.

Cable the analog inputs and outputs between the Model 493.10 chassis and a 407 controller as follows:

Note *Analog I/O connectors are located on the rear panel of the chassis.*

1. Connect a 493.76 Analog Out BNC connector to the program (analog) input on the 407 Controller. Connections for single or multiple 407 controllers are shown.
2. If you will monitor sensor feedback for data acquisition or control feedback, connect the external controller's conditioner output to a 493.77 Filtered Analog Input BNC connector.

   For conditioner output locations on various MTS devices, see "Sample conditioner output connections" on page 92.

WARNING

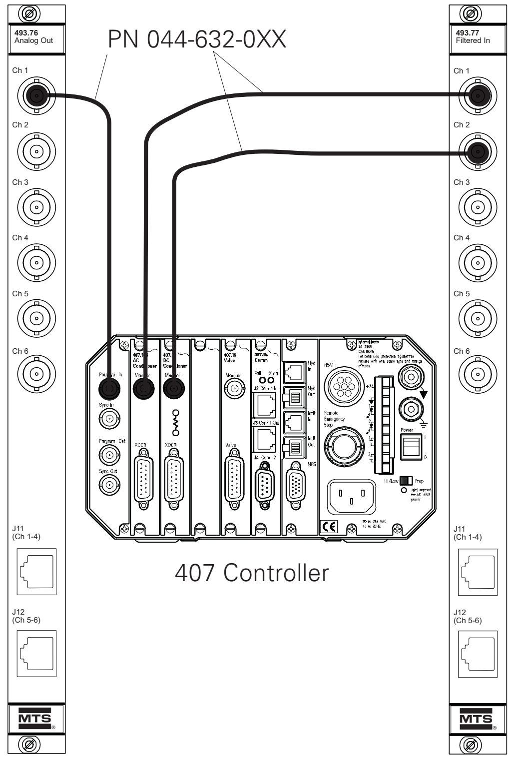
Do not interrupt Model 493.10/793 controller power when you are programming another controller. A power interrupt may cause the external controller to react to a zero command and move the actuator unexpectedly.

Ensure power cannot be removed accidently while a test is in progress.

For more detailed information about analog I/O connections, see "Analog I/O Connections" on page 52.

Single 407 Controller Connections

Transition modules on the rear panel of the Model 493.10 chassis are used for analog inputs and outputs.



493.76 Analog Out

This module includes 6 BNC connectors that provide analog outputs from a Model 493.46 D/A daughter card.

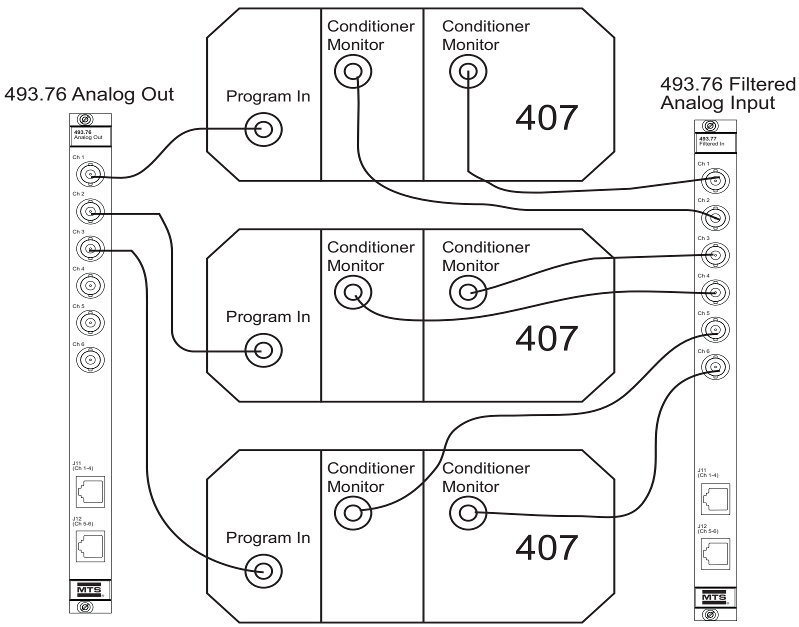
Six analog outputs are available with each D/A daughter card installed on the Model 493.40 I/O Carrier module.

493.77 Filtered Analog Input

This module includes 6 BNC connectors that provide filtered analog inputs to a Model 493.45 A/D daughter card.

Six analog inputs are available with each A/D daughter card installed on the Model 493.40 I/O Carrier module.

Multiple 407 Controller Connections



Sample conditioner output connections

This table shows connector assignments for various MTS products you can use with your Model 493.10/793.00 controller.

Conditioning Sensors with Other MTS Products

MTS PRODUCT	SENSOR OUTPUT
Model 408.81 Testing Panel/ Model 408.82 DC Conditioner	Sensor output is available at the rear-panel connector **J201** or **J202**.
Model 409.81C Temperature Controller	Temperature output (via an analog signal) is available at rear-panel connector **J1**.
Model 448.82/85 Test Controller with Model 448.21/22 AC and DC Conditioners	Sensor output is available at rear-panel connector **J335**. Ensure sensor conditioners are set as follows: X1: 2&3 X2: 2&3
Model 458.10/20 MicroConsole® with Model 458.11/12/13/14 AC and DC Controllers	Sensor output is available at the MicroConsole rear-panel connector **Jx03**. Connector **Jx03** represents the module location (J100–J600). MicroConsole jumper Jx00 should be set to 1&2 (standard setting).

Task 2 Create your configuration file with Station Builder.

Using Station Builder, define controller resources to provide programming to an external controller.

Refer to “How to Create Your Station Configuration File” and “Creating Program Channels” in Chapter 2, Station Builder of the *Model 793.00 System Software* manual for more detailed information.

Task 3 Adjust the signals with Station Manager.

Adjust Program Signal

Adjust the outgoing program signal for the required external controller channel.

Refer to “How to Adjust Program Output Signals” in Chapter 3, Station Manager of the *Model 793.00 System Software* manual.

Adjust Feedback Signals

If you will monitor sensor feedback for data acquisition or control feedback, adjust the incoming feedback signals.

Refer to “How to Configure an Externally Conditioned Feedback Signal” in Chapter 3, Station Manager of the *Model 793.00 System Software* manual for more detailed information.

Task 4 Set up your program.

Define a program with the Function Generator, Basic TestWare, or Multipurpose TestWare applications.

Using Function Generator

Refer to “How to Program with the Function Generator” in Chapter 3, Station Manager of the *Model 793.00 System Software* manual.

Using Basic TestWare

The Basic TestWare application allows you to create simple test programs that do not require complex signal management or mode switches for station configuration files.

Refer to “Defining the Test Command” in Chapter 4, Basic TestWare of the *Model 793.00 System Software* manual.

Note *It is good practice to use tapered wave shapes to apply the program command to the external controller slowly.*

Using MultiPurpose TestWare

To create more sophisticated test programs use the optional MultiPurpose TestWare application.

Refer to the *Model 793.10 MultiPurpose TestWare* manual for more detailed information.

Cabling

Connecting Interlock Signals to 407 Controllers

The Model 493.10/793.00 controller monitors digital I/O interlock signals through its Model 493.74 HSM transition module's **J43A** and **J43B** connectors. Use these connectors when connecting to 407 controllers.

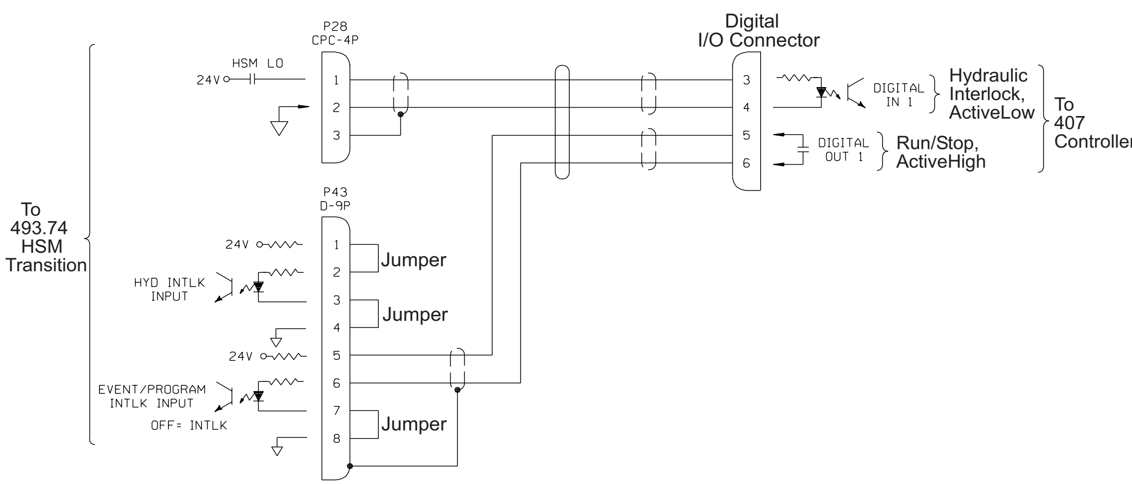
Model 493.74 HSM transition module connectors are as shown in the figure.

Interlock cabling to 407 controllers depends on your system's configuration. There are three possible configurations:

- Single station—one 407 controller runs a single test program.
- Multiple stations—two or more independent 407 controllers each run different test programs.
- Master-dependent station—one master 407 controller daisy-chained with other dependent 407 controllers together run a single test program.

Single 407 Controller Interlock Connections

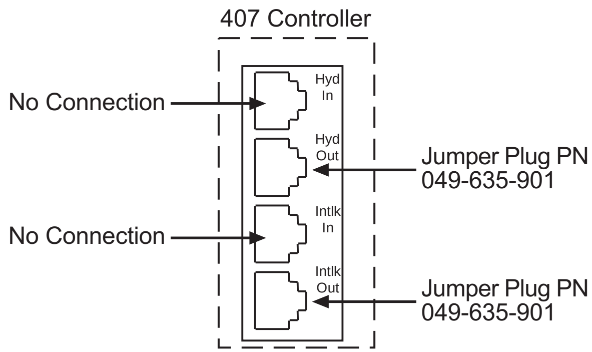
The following figure shows how to cable interlocks for a single station 407 controller to the Model 493.10/793.00 controller (via its Model 493.74 HSM transition module). Use the specified interlock cable (PN 56455-0xx) to make these connections.



Interlock Cable PN 56455-0XX

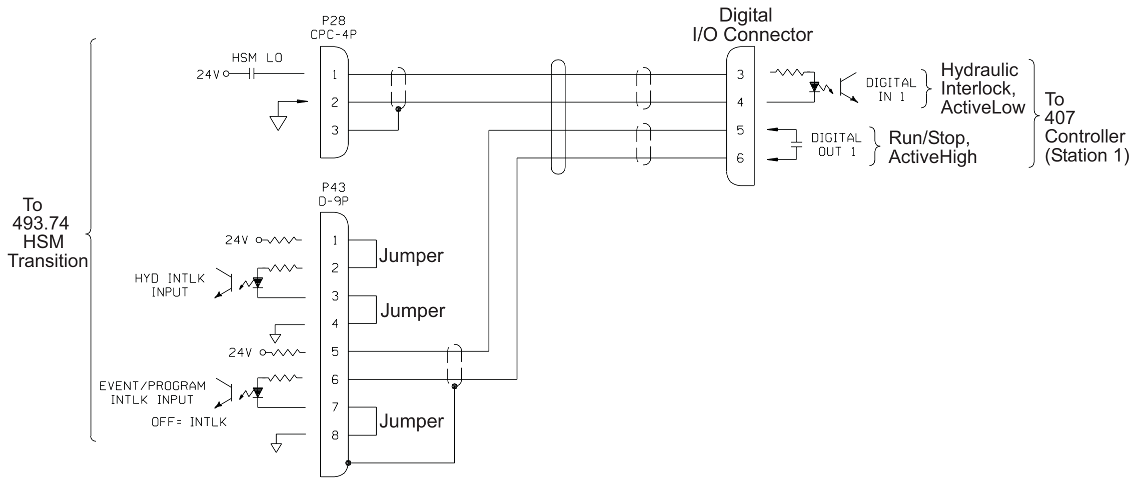
How to Jumper the Hydraulic Terminal on a Single Station 407

The following figure shows how to cable the hydraulic terminal on a single station 407 controller.

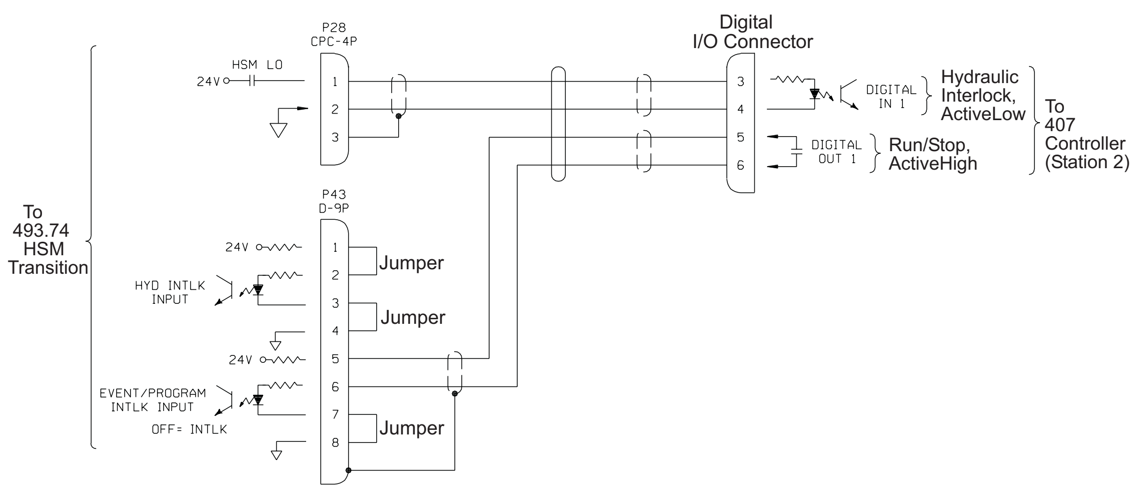


Multiple 407 Controller Interlock Connections

The following figure shows how to cable interlocks for multiple 407 controllers to the Model 493.10/793.00 controller (via its Model 493.74 HSM transition module). Use the specified interlock cable (PN 56455-0xx) to make these connections for each 407 controller station..



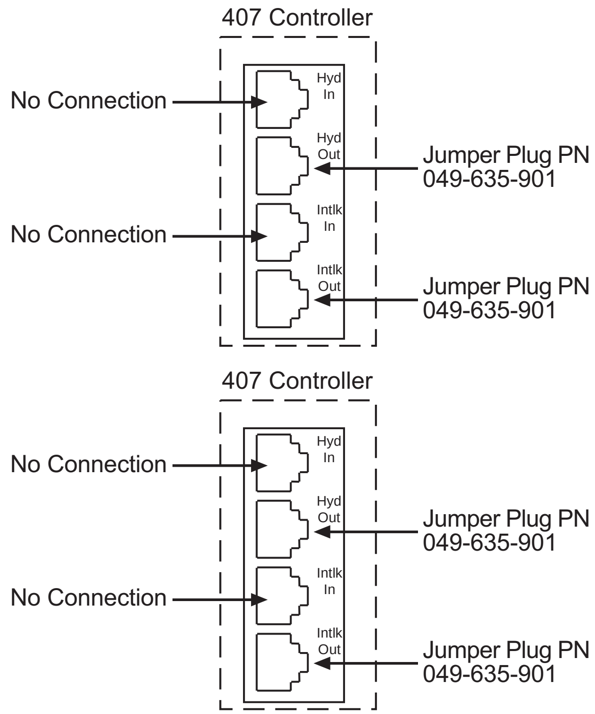
Interlock Cable PN 56455-0XX



Interlock Cable PN 56455-0XX

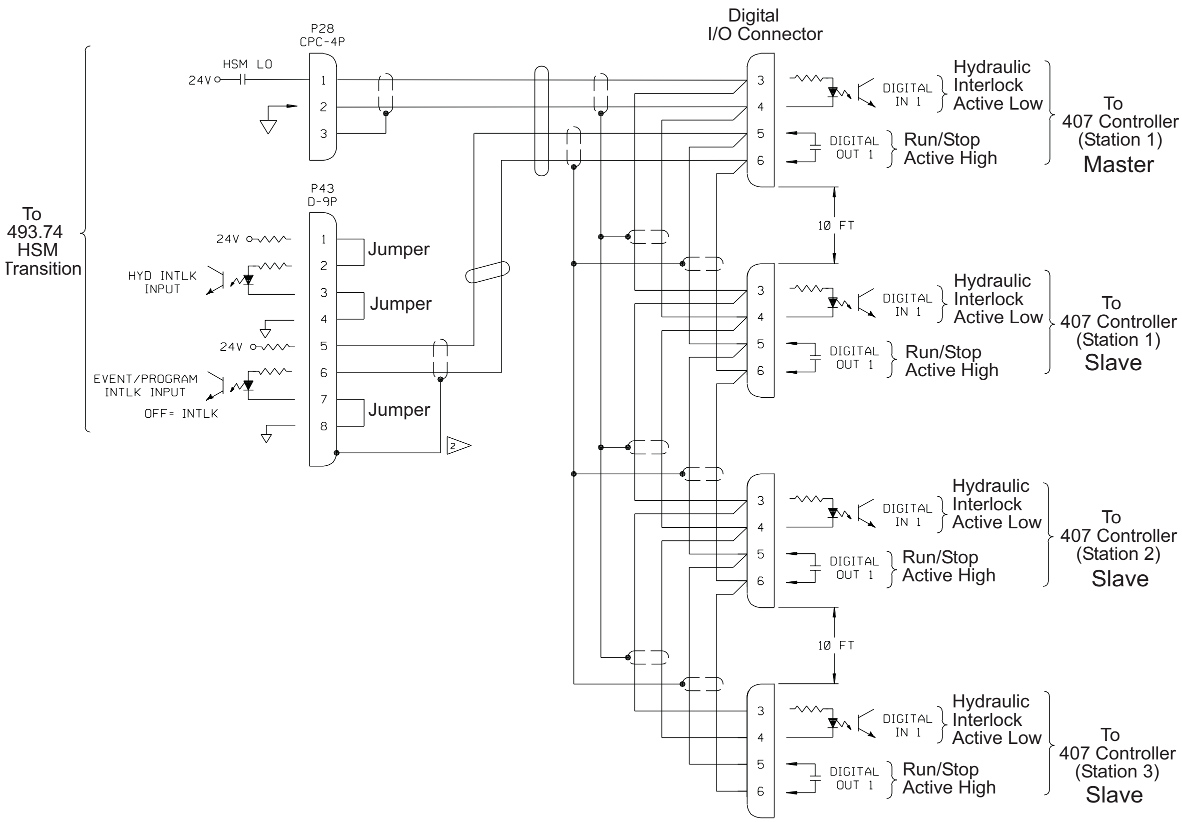
How to Connect Hydraulic Terminals on Multiple Station 407s

The following figure shows how to cable hydraulic terminals on multiple station 407 controllers, where each 407 controller can run an independent test program. Repeat this scheme for each additional 407 controller.



Interlock Connections for Master/Dependent 407 Controllers

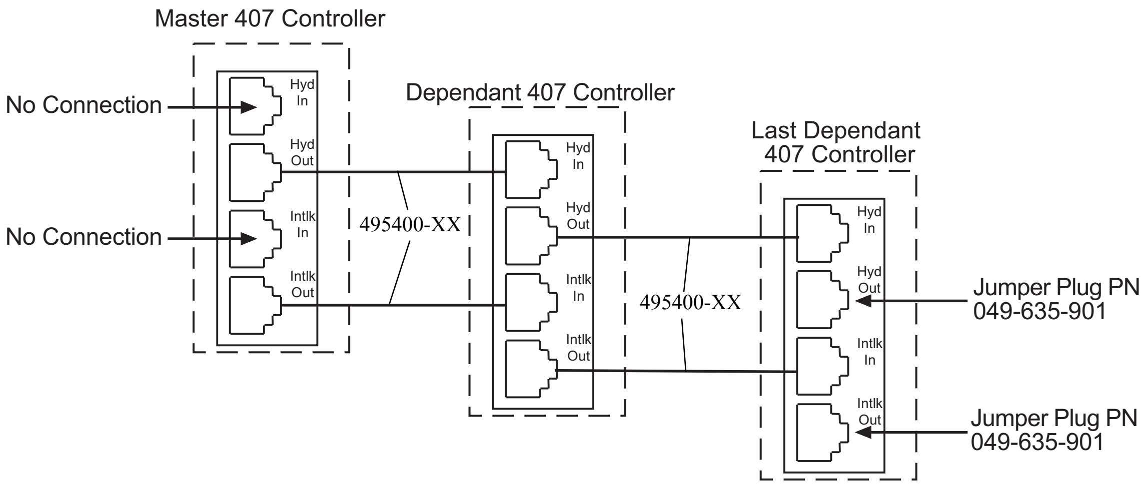
The following figure shows how to cable interlocks when a master 407 controller is daisy-chained with three other dependent 407 controllers to run a single test program on the Model 493.10/793.00 controller (via its Model 493.74 HSM transition module). Use the specified four-channel master/dependent interlock cable (PN 564489-XX) to make these connections for each 407 controller station.



Master/Dependent Interlock Cable
(PN 564489-XX)

How to Connect Hydraulic Terminals on Master-Dependent 407s

The following figure shows how to cable hydraulic terminals on three 407 controllers in a master-dependent daisy-chain. Note that the last dependent controller in any daisy-chain must have jumper plugs installed in its **Hyd Out** and **Intlk In** terminals.



Setting Up a 407 to Receive and Send Signals

After cabling the 407, you must configure it to receive and send signals from the Model 493.10/793.00 controller. The tables below list typical menu settings. Refer to the *407 Controller Product Information Manual* for more information.

407 Configuration Menu

Parameter	Setting
Eng Units	—
EOC Act	—
CYC Src	PROGRAM
SetPt R	150%/s (or highest)
Span R	300%/s (or highest)
Hyd Cnfg	—
Intlk Cnfg	MASTER*
P/V Sens	—
Span Cnfg	1X
CMD Sel	EXT IN
Prog Out	—

* Always designate one 407 in a station as a MASTER. If there are other 407s in the same station, daisy-chain their interlocks designate them as DEPENDENT.

407 Function Generator Menu

Parameter	Setting
Wvform	EXTERN
Freq	—
Setpnt	—
Span	—
Preset	—

407 Amplitude Control Menu

Parameter	Setting
Ampl Cntrl	OFF
Fdback	—
Mean	—
Ampl	—
AMC Gain	—

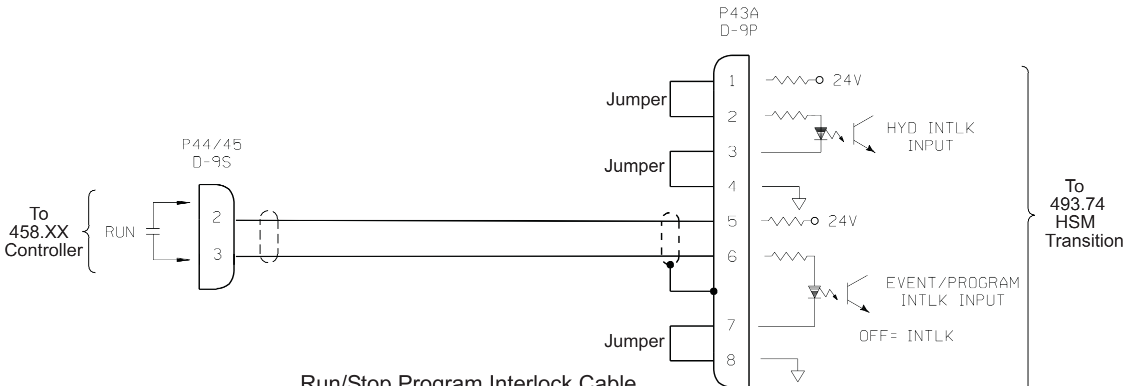
407 Digital I/O Menu

Parameter	Setting
Din1 Definition	Program in RUN
Din1	RUN/STOP
Din1Pol	ACT HI
Din2 Definition	Hydraulic Interlock
Din2	Interlock
Din2Pol	ACT LOW
Dout1 Definition	Hydraulics ON*
Dout1	HYD OFF
Dout1Pol	ACT LOW
Din2 Definition	—
Dout2	—
Dout2Pol	—

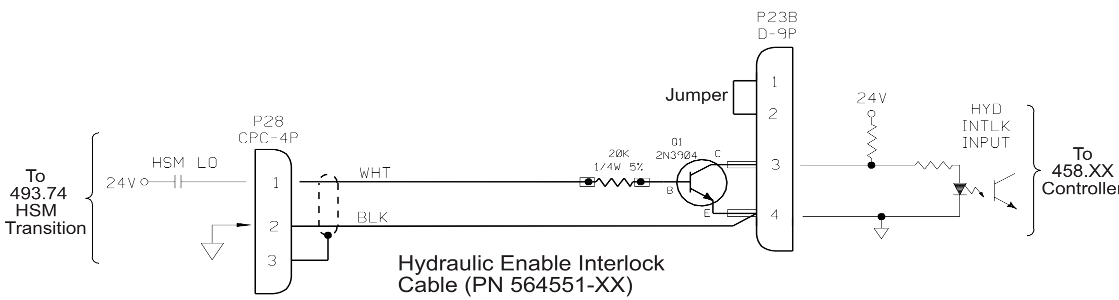
* Or Run/Stop (ACT HI), Interlock (ACT LOW), None (ACT HI).

Connecting Interlock Signals to 458 Controllers

The Model 493.10/793.00 controller monitors digital I/O interlock signals through its Model 493.74 HSM transition module.



Run/Stop Program Interlock Cable (PN 564552-xx)

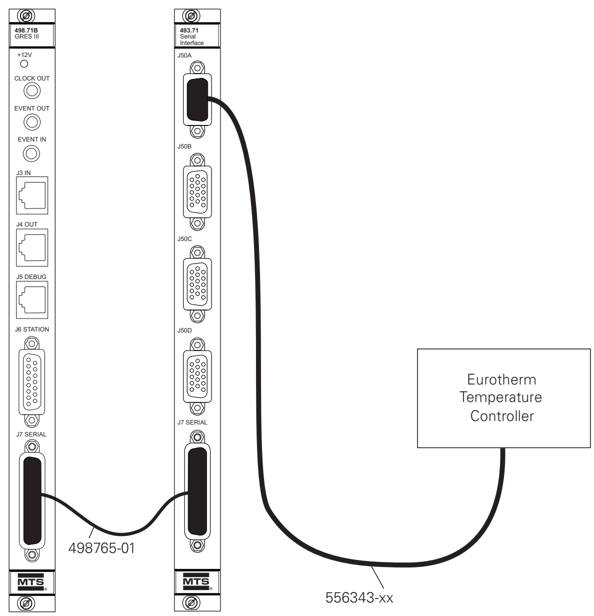


Hydraulic Enable Interlock Cable (PN 564551-XX)

Eurotherm Temperature Controller Connection

When equipped with a Model 498.71B GRES III plug-in module, your Model 793.00 controller can program and control one or more Series 2200/2400 Eurotherm Temperature Controllers via the **J50** serial connectors on a Model 493.71 Serial Interface transition module.

In order to use this configuration, a special temperature controller resource must be added to your .hwi file.



J50 connectors

The temperature controller can be connected to any of the four **J50** connectors on the serial interface.

Temperature controller hardware resource

For more information on adding the Eurotherm .hwi file resource, see “Temperature controller” on page 307.

Program Eurotherm Temperature Controller

Use Station Builder to configure a Eurotherm temperature controller.

Refer to “How to Program a Eurotherm Temperature Controller” in Chapter 2, Station Builder of the *Model 793.00 System Software* manual for detailed information.

Cabling for External Command Inputs

Cabled properly, your FlexTest controller can receive programming from an external controller.

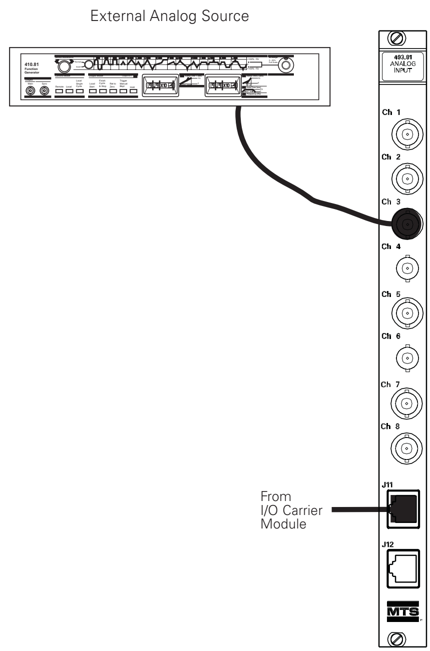
How to Enable and Run External Command Inputs

To enable an external command source, perform the following:

1. "Cable the controllers." on page 106.
2. "Allocate external command resources in Station Builder." on page 106.
3. "Adjust the command signal with Station Manager." on page 107.
4. "Start the External Command." on page 107.

Task 1 Cable the controllers.

Cable the external programmer analog out connector to a Model 493.75 Analog In module BNC connector.



Task 2 Allocate external command resources in Station Builder.

Using Station Builder, allocate controller resources to receive programming from an external controller.

Refer to “Enabling External Command Inputs” in Chapter 2, Station Builder in the *Model 793.00 System Software* manual for more detailed information.

Task 3 Adjust the command signal with Station Manager.

Refer to “How to Enable and Run External Command Inputs” in Chapter 3, Station Manager in the *Model 793.00 System Software* manual for more detailed information.

Task 4 Start the External Command.

Refer to “How to Enable and Run External Command Inputs” in Chapter 3, Station Manager in the *Model 793.00 System Software* manual for more detailed information.

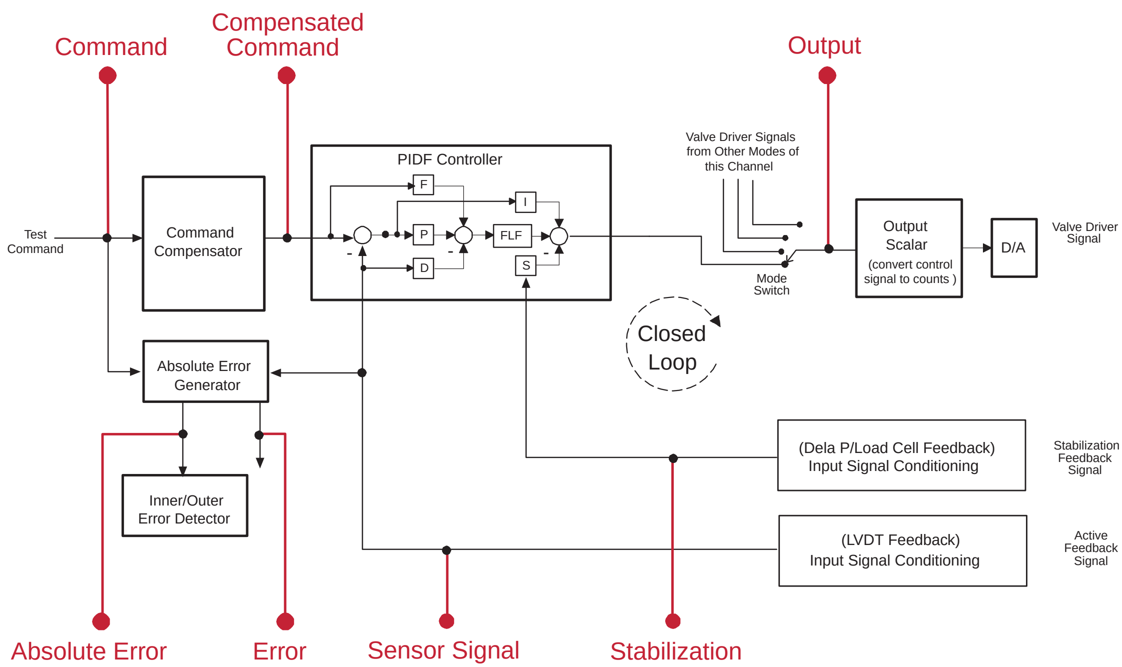
Cabling and Using External Readout Devices

Cabled appropriately, your controller can send station signals to external readout devices such as oscilloscopes and digital-volt-meters. You define which signal is sent to the readout device with the **Adjust Readouts** window.

Refer to “About Monitoring Signals Using External Readout Devices” in Chapter 3, Station Manager of the *Model 793.00 System Software* manual for more information.

Station signal diagram

The block diagram identifies the station signals you can monitor.



Station signal descriptions

Except for time and auxiliary data signals, station signals listed in your software windows include the name of their associated control channel. For example, if your channel is labeled **Ch. 1**, the available station signals would be **Ch.1 Output**, **Ch. 1 Command**, and so forth.

The following table provides a description of the various station signals.

SIGNAL	DESCRIPTION
Time	Displays the time reference signal derived from the internal clock that increments continually. This signal exists to support data acquisition by test program applications, such as Basic TestWare and MultiPurpose TestWare. It is not practical to monitor the time signal with an external readout device.
Rollover Time	Displays the time reference signal derived from the internal clock that resets every hour. Like the time signal, this signal exists to support data acquisition by test program applications. It is not practical to monitor the hourly rollover time with external readout devices.
Output	Displays the test control signal sent to the valve driver in volts.
Command	Displays the program command signal in engineering units.
Comp. Cmd	Displays the value of the compensated command signal in engineering units. This signal is only valid when using Peak/Valley, AIC, APC, or ALC compensators.
Count	Displays the number of segments played out so far in the selected control channel. When using a Station Manager meter, this signal is only available for the Timed meter.
Error	Displays the error signal in engineering units. The error is the difference between the command signal and the sensor feedback signal.
Abs. Error	Displays the absolute value of the error signal in engineering units.

How to Send Signals to External Readout Devices

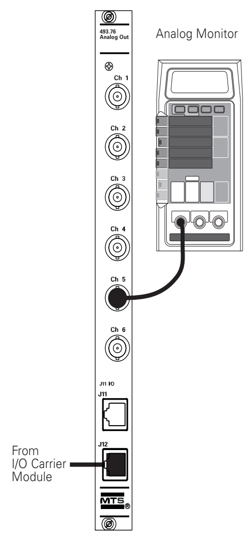
To send station signals to an external readout device, you must:

1. "Cable your controller to the readout device." on page 110.
2. "Create a readout channel with Station Builder." on page 111.
3. "Adjust the readout signal in Station Manager." on page 111.

Task 1 Cable your controller to the readout device.

Cable your FlexTest IIm/CTC analog output connector to the readout device. Analog I/O connectors are located on the rear of the test processor chassis.

Connect an external readout device analog input to a BNC connector on a Model 493.76 Analog Out module.



Task 2 Create a readout channel with Station Builder.

Refer to “How to Create a Readout” in Chapter 2, Station Builder of the Model 793.00 System Software manual for a detailed procedure.

Task 3 Adjust the readout signal in Station Manager.

Use Station Manager to adjust the readout signal.

For a detailed description of readout signal configuration and adjustment, refer to “How to Configure a Signal for External Readout” Chapter 3 in Station Manager of the *Model 793.00 System Software* manual.

Chapter 4

Servovalve Controls

This chapter describes servovalve adjustments that optimize the interface between the controller and the servovalve.

Contents

Hydraulic systems

Hydraulic systems use servovalves to control the actuator. The following complement of valves have different **Drive** panels:

- **252 Valve**—represents the MTS Series 252 Servovalve.
- **Dual 252 Valve**—represents two MTS Series 252 Servovalves mounted to the actuator manifold.
- **256/257 Valve**— represents the MTS Series 256 and Series 257 Servovalves. Although these valves are different, they use the same adjustments. These servovalves have inner control loops.

Adjustment prerequisites

You should run a small program to warm up the system hydraulic fluid and servovalve before you adjust the valve balance, dither, or inner loop.

Refer to "How to Warm Up the System Hydraulics" in Chapter 5, Tuning of the *Model 793.00 System Software* manual for a detailed procedure.

When to adjust

You make servovalve adjustments to optimize the valve response to your program commands.

Normally, servovalves are balanced and tuned at the factory, and then optimized by the MTS service engineer who installs your system. However, if you change or replace a hydraulic component or notice erratic servovalve response during a test, you may need to readjust your servovalve settings.

Use the following paragraphs to determine when to perform each servovalve adjustment.

Note *During system installation, perform all of the adjustments in this section.*

Initial adjustments

Perform initial adjustments when initially installing the system or replacing a hydraulic component. These adjustments, such as setting servovalve polarity, are only needed once and should not require readjustment.

See "Setting the Servovalve Polarity" on page 115.

.Valve balance

While running a test on a properly tuned system, you observe that the controlling sensor's peak and valley amplitudes are unequal. When you have completed a mechanical valve adjustment, always adjust the valve balance.

See "Adjusting Valve Balance" on page 117.

Dither

Adjust the dither while running a test on a properly tuned system, you observe either of the following:

- A sinusoidal test waveform is distorted at its maximum and minimum points (peak and valley values change). This will normally be more observable during a test that has either a low-frequency or a low-amplitude test waveform. This indicates that dither amplitude is insufficient.
- An unusual sound (hammering, squealing, or pounding) coming from the test system. This indicates that dither amplitude is excessive.

See "Adjusting dither amplitude" on page 118.

Inner loop tuning

Perform inner loop tuning when initially installing a system or fine tuning a system that employs a 3-stage valve driver.

See "Tuning the Inner loop" on page 119.

Setting the Servovalve Polarity

Servovalve polarity determines the direction the servovalve moves the actuator in response to a positive command. It can be set to normal or invert.

Typically, a servovalve set to normal polarity extends the actuator in response to a positive command. Conversely, a servovalve with an inverted polarity retracts the actuator in response to a positive actuator command.

Before you can set servovalve polarity, you must determine if the current servovalve polarity follows the normal convention.

Please note the following:

- The polarity of the servovalve must be checked before sensor calibration begins and before hydraulic pressure is applied for the first time.
- The polarity of any servovalve is generally set when the valve is installed.

Important The combination of the conditioner polarity and the servovalve polarity affects the final output signal. The conditioner polarities should be set before the servovalve polarity because they do not need hydraulics to be turned on. In general, you will set the conditioner and servovalve polarity the same.

Procedure This procedure allows you to determine servovalve polarity by observing actuator movements while applying a positive Setpoint command to the actuator.

Refer to "How to Set Servovalve Polarity" in Chapter 5, Tuning of the *793.00 System Software* manual for a detailed procedure.

Getting Things Ready

If you plan to perform any of the procedures described later in this chapter, be sure that you get the hydraulic fluid up to temperature.

Be sure that both the hydraulic fluid and the servovalve are at operating temperature. Remove any specimen and run the system in displacement control for at least 30 minutes using an 80% full-scale length command at about 0.1 Hz.

Refer to "How to Warm Up the System Hydraulics" in Chapter 5, Tuning of the *Model 793.00 System Software* manual for a detailed procedure.

Adjusting Valve Balance

The valve balance adjustment electrically compensates for minor electrical and mechanical imbalance in the servovalve.

Your servovalve is typically balanced during installation at its midstroke position. The signal values in your station parameter set reflect that initial servovalve balance procedure.

For optimal performance, you should balance your servovalve again after you position your actuator to the test start position.

Prerequisites

The following must be true. If not, go to "Getting Things Ready" on page 116.

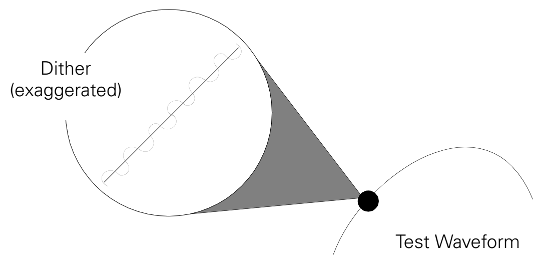
- The hydraulic fluid and the servovalve are at operating temperature.
- Command compensators are turned off.

Procedure

Refer to "How to Check and Adjust Valve Balance" in Chapter 5, Tuning of the *Model 793.00 System Software* manual for a detailed valve balancing procedure.

Dither

Dither is a low-amplitude, high-frequency sine wave that your controller applies to your servovalve's spool. Dither keeps your servovalve's spool in motion so it operates smoothly and does not silt up or stick to its cylinder walls. It is especially useful for tests that use small amplitude commands or run at low frequencies.



Dither amplitude was set during installation. The signal values in your station parameter set reflect that initial dither amplitude procedure, and are probably adequate for your test.

The following are signs of an improper dither adjustment:

- **Dither amplitude is too low**—While running a sinusoidal test on a properly tuned system, you notice that the waveform distorts at its maximum and minimum points. This will normally be more apparent during a test that has either a low frequency or a low amplitude test waveform.
- **Dither amplitude is too high**—You hear unusual sounds, such as hammering, squealing, or pounding coming from the test system.

Dither adjustment prerequisites

The following must be true. If not, go to "Getting Things Ready" on page 116.

- The hydraulic fluid and the servovalve are at operating temperature.
- Command compensators are turned off.

Adjusting dither amplitude

Refer to "How to Check and Adjust Dither Amplitude" in Chapter 5, Tuning of the *Model 793.00 System Software* manual for a detailed dither amplitude adjustment procedure.

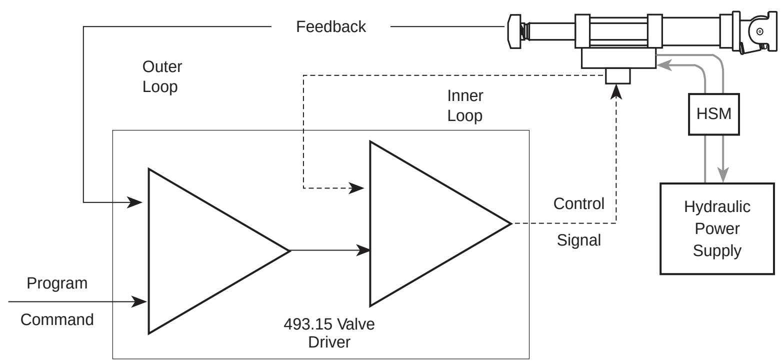
Tuning the Inner loop

Perform inner loop tuning when initially installing a system or fine-tuning a system that employs 3-stage valve drivers. The inner loop proportional gain and rate derivative adjustments are the same types of adjustments as used with the PIDF tuning controls.

Note *During initial system installation, inner loop gain and rate adjustments must be performed before tuning the servo outer loop. For fine tuning, an initial inner loop gain adjustment may be needed if the outer loop is sluggish.*

The inner control loop is similar to a displacement control mode for the outer loop. The Model 493.15 Three-Stage Valve Driver module includes the electronics necessary to support the inner control loop.

The innerloop (proportional) gain and rate (derivative) adjustments are the same types of adjustments as the proportional and derivative gain adjustments of the outerloop tuning controls.



Important

Always tune the inner loop without the hydraulics applied to the actuator. Perform the inner loop gain adjustments with hydraulic pressure removed from the main spool while maintaining pressure at the pilot stage. This prevents interaction between the inner and outer loops.

Procedure

For a detailed inner loop tuning procedure, refer to “How to Tune the Inner Loop of Three-Stage Valves” in Chapter 5, Tuning of the *Model 793.00 System Software* manual

Zero the Spool Position Signal

This task matches the electronic null of the spool position signal with the mechanical null position of the servovalve pilot spool.

During inner loop tuning, it may be necessary to complete this procedure if the spool position signal voltage is not approximately equal (though opposite polarity) at opposite endcaps of a servovalve.

1. On the **Drive** panel, click the **Valve** tab.
2. Set the **Valve Balance** to zero.
3. On the **Drive** panel, click the **Conditioner** tab.
4. Ensure that the **Offset** control is set to zero.
5. Apply hydraulic pressure.

WARNING

Do not remove the LVDT adjustment locknut or assembly when adjusting the servovalve LVDT spool position.

If it is removed, hydraulic fluid will spray from the servovalve at full pressure. You should refer to the servovalve product manual to identify the main stage LVDT spool adjustment.

6. Loosen (but do not remove) the LVDT locknut.
7. Adjust the LVDT in or out of the servovalve to provide a zero spool position signal.
8. Tighten the locknut while holding the LVDT in position.

Inner Loop Signals

For detailed information about monitoring inner loop signals on TestStar™ IIm and FlexTest™ GT Controllers, see "Inner Loop Signals" in Chapter 5, Tuning of the *Model 793.00 System Software* manual.

Chapter 5

Sensors

This chapter describes sensor signals, connections, and cabling. Shunt calibration for DC sensors is described for systems with and without ID modules on their sensor cables.

Transducer ID modules are also discussed including assigning sensors and saving data to ID modules.

Contents

Sensor Signals

With the Station Builder program, you can allocate station resources (conditioners) to sensors connected to your test system. Once a conditioner is linked to a sensor, the sensor signal (feedback) can be used as a control mode and/or for data acquisition. Available sensor signals vary with the type of controller in your system.

TestStar™ IIm and FlexTest™ GT controllers support the following types of sensor signals:

- *AC conditioner* signals are conditioned by a Digital Universal Conditioner (DUC) daughter board plugged into the I/O Carrier module on the 493.10 chassis. The DUC must be configured for the AC mode. An LVDT requires AC conditioning.
- *DC conditioner* signals are conditioned by a Digital Universal Conditioner (DUC) daughter board plugged into the I/O Carrier module on the 493.10 chassis. The DUC must be configured for the DC mode. A force transducer (load cell) requires DC conditioning.

About Sensor Ranges and Detectors

Sensor description

Your system's sensors convert measured mechanical values, such as force, displacement, and pressure, into electrical signals that after conditioning, are suitable for feedback for closed-loop control. Sensors and sensor conditioners are calibrated together in pairs against a standard to ensure their outputs accurately represent the physical properties they are measuring.

Sensor ranges

Every sensor has a full-scale capacity that defines its maximum operating range. For example, an actuator that can extend its piston 6 cm from its fully retracted position is referred to as an actuator with a "6-cm stroke." The displacement sensor used with the actuator has a full-scale capacity of 6 cm.

Full-range conditioners

Some sensor conditioners, such as Model 493.25 Digital Universal Conditioners, are full-range conditioners. They have only one range that spans the sensor's full-scale capacity.

Ranged conditioners

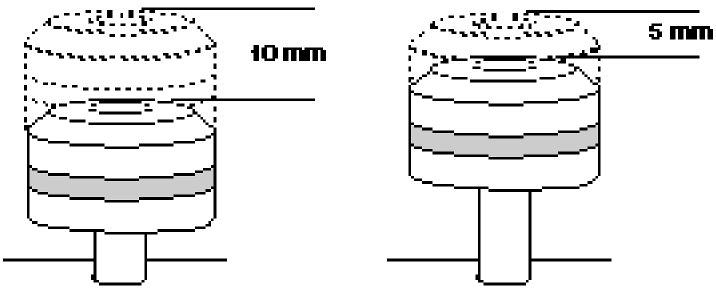
Certain conditioners, such as the Model 493.21B AC/DC Universal Conditioner, use two or more ranges. Each range defines the electronic amplitude of the sensor's feedback signal for the purpose of providing better signal resolution. In other words, it redefines the input channel to represent a portion of the sensor's physical capacity.

With this type of sensor conditioner, you may create a range for any portion of the sensor's capacity. Typical ranges are: Range 1, 100%; Range 2, 50%; Range 3, 20%; and Range 4, 10%.

Range example

Each sensor can be calibrated for different ranges. A range redefines the input channel to represent a portion of the sensor's physical capacity. You can create a range for any portion of a sensor's capacity.

Ranges represent a portion of the sensor's capacity.

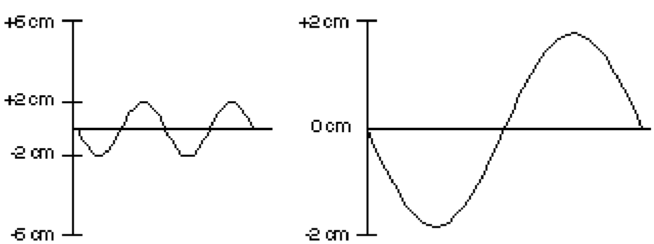


Suppose a displacement sensor has a full-scale capacity of 10 mm. A ±5 mm range can operate across the full-scale range of the sensor (±5 mm). A ±2.5 mm range of the same sensor can operate across half the capacity of the sensor (this redefines full scale to be ±2.5 mm).

Selecting ranges

Be sure you select a range large enough to accommodate the maximum sensor output expected during a test.

Select a full-scale range to optimize the maximum sensor output for a test.



Example: Suppose your test requires a ±2.0 cm displacement. A ±6 cm or ±3 cm range functions properly, but a ±2 cm range provides the best resolution.

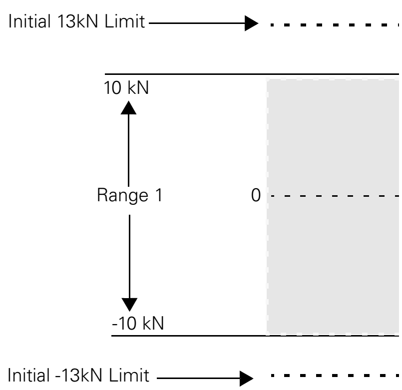
Sensors

When setting up a test, it is good practice to select a range slightly larger than the largest value expected for the test. The smaller the range, the better the resolution of the sensor's signal.

Initial limit detectors for each range

When you select a range, the initial setting of the associated limit detectors are ±130% of the range value. For example, suppose you select Range 1 of your system's force sensor, and that Range 1 is ±10 kN. In this case, the initial placement of the limit detectors will be ±13 kN.

The application places the initial limit detectors at ±130% of the selected range (as shown).



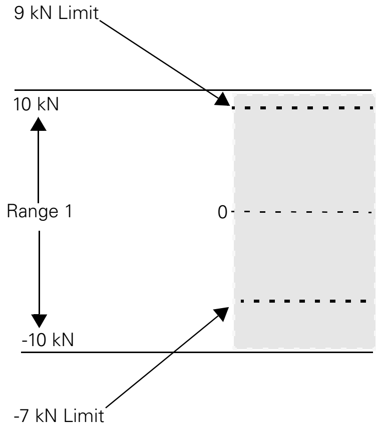
By default, limit detectors are initially disabled. So even if you enable a limit detector at its initial setting (±130% of its range value), it still will not work because the sensor conditioner's hardware will saturate before attaining ±130% of the current range.

Enabling limit detectors

To allow a limit detector to work in a given range, you must:

- Change its limit value so that it falls within ±100% of its range, and
- Enable it (change its selected action from “Disable” to the desired action)

To make a limit detector work, you must change its initial setting so that it is within ±100% of the selected range (as shown).



To set error and limit detectors, see “How to Set Limit Detectors” and “How to Set Error Detectors” in Chapter 3, Station Manager of the *Model 793.00 System Software* manual.

Be aware of detector settings when changing ranges

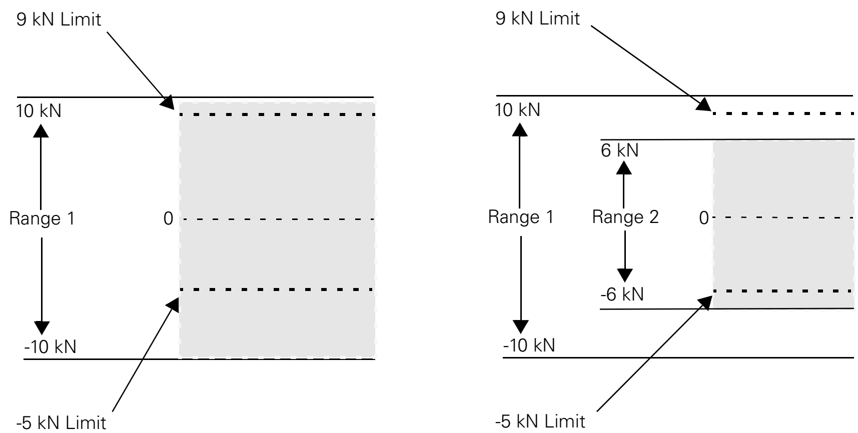
When you go from a larger range to a smaller range, limit detector do not automatically change, so they may not apply to your new range.

When this occurs, the controller will display the following message:

> “The range selected for signal ‘signal name’ has left one or more of the signal's detectors outside of the new range.
>
> Please verify that the detectors (limit and error) associated with this signal are adjusted as necessary.”

For example, suppose you have a configuration in which Range 1 spans ±10 kN, with limits set at 9 kN and -5 kN, as shown below in the figure to the left. Both limits are viable for Range 1.

Next, suppose you select Range 2, which spans ±6 kN, as shown below in the figure to the right. In this case, the 9 kN limit would not be applicable to Range 2, and the application would display the message. However, the -5 kN limit still falls within the span of Range 2.



When you select a new range, review the limits you have defined for the selected signal to ensure they are appropriate for your new range.

Transducer Connections

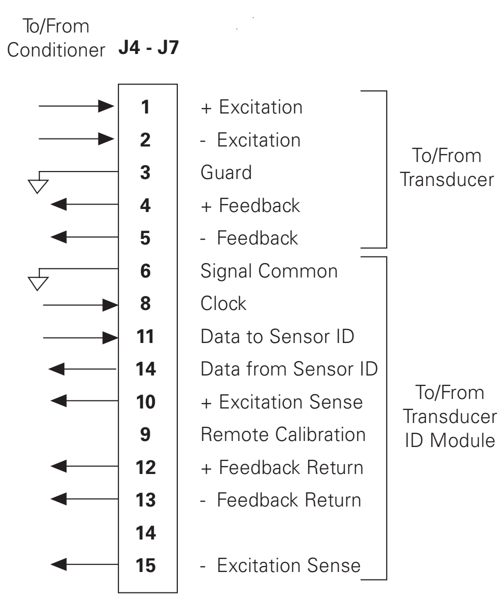
Transducer connections require a conditioner daughter board be installed in the I/O Carrier module. The following conditioners can be installed:

- Model 493.21B Digital Universal Conditioner
- Model 493.25 Digital Universal Conditioner
- Model 493.47 Encoder
- Model 493.48 Acceleration Conditioner

Each Model 493.40 I/O Carrier module can include up to four daughter boards. Each installed daughter board is assigned a specific I/O Carrier module front panel connector (**J4–J7 I/O**). These connections can be used for any type of sensor (provided the appropriate daughter board is installed).

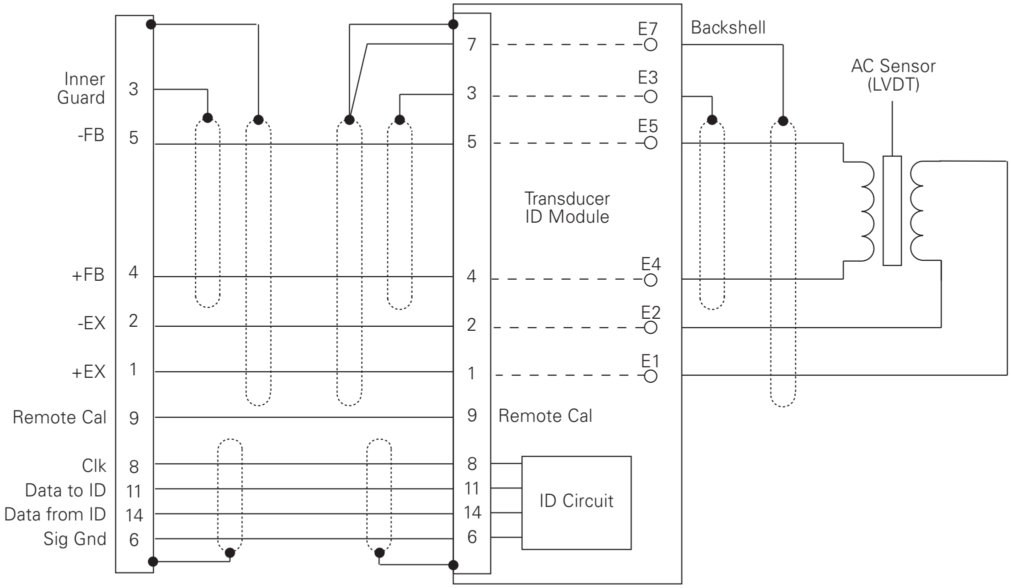
A hardware interface file (.hwi) defines each type of module (and their associated daughter boards) and maps each module location for the system software. The .hwi file and the physical locations for each type of module and associated daughter boards must match. For more information on the .hwi file, see “The .HWI File” on page 283

If purchased as an option, a transducer ID module is located in the transducer cable. Excitation and feedback signals are passed through to the transducer.



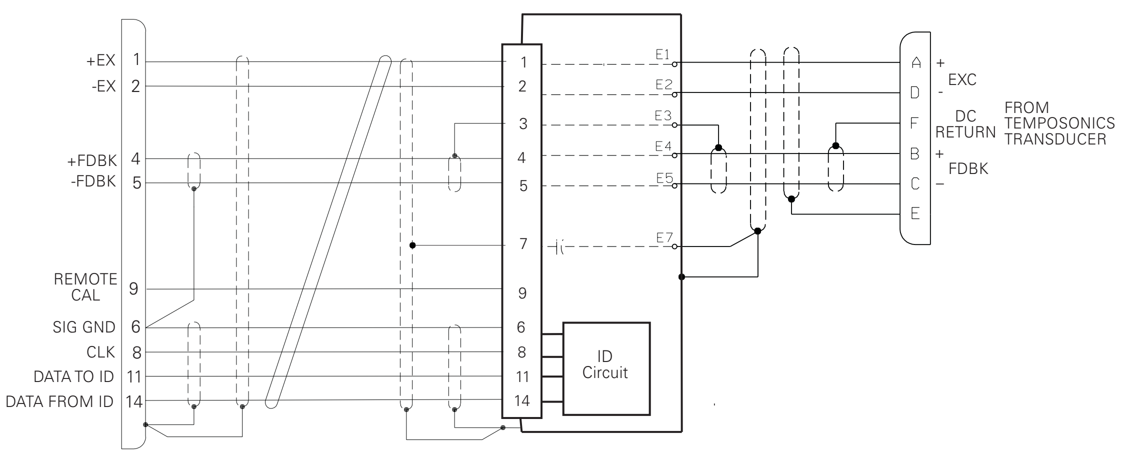
LVDT connections

An LVDT requires an AC conditioning daughter board.



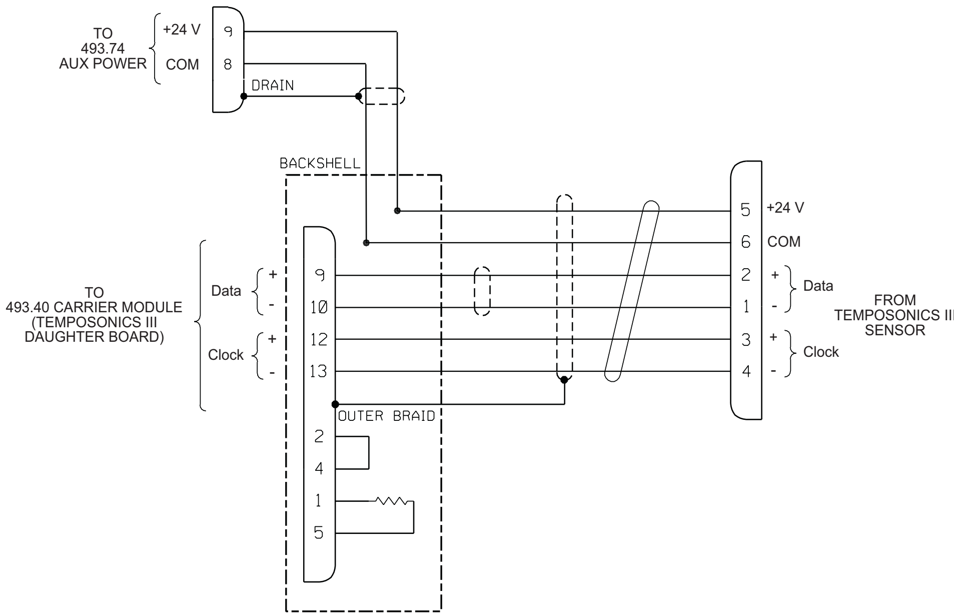
Temposonics II connections

A Temposonics II transducer requires a DC conditioning daughter board.



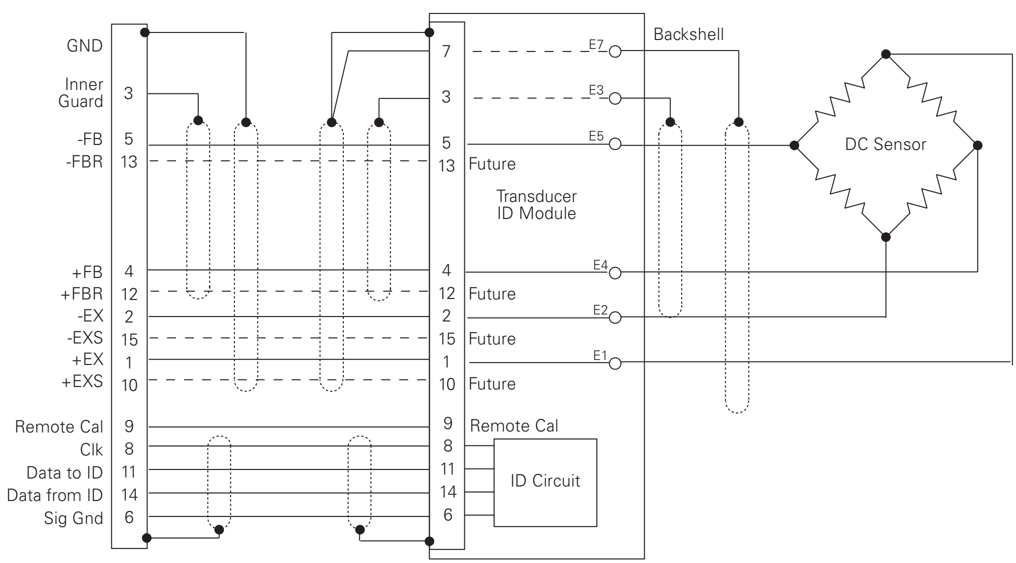
Temposonics III connections

A Temposonics III transducer requires a DC conditioning daughter board.



Force/strain sensor connections

Force and strain sensors require a DC conditioning daughter board.



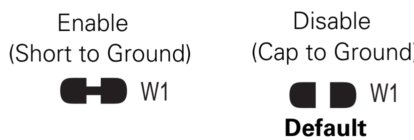
Full-Range Digital Universal Conditioner (FRDUC) Jumpers

The following jumpers are for the Model 493.25 Full-Range Digital Universal Conditioner. The jumpers are labeled W instead of X; the W jumpers are solder pads. The following jumper descriptions are from the 493.XX Module Setup configuration drawing (PN 493363-01).

Active guard

Jumper W1 enables or disables an active guard for the sensor cable.

- A passive guard drive is the default.

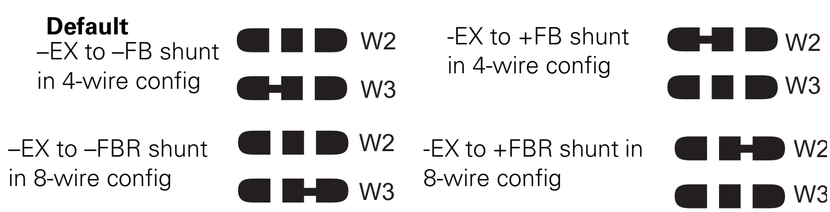


4- or 8-Wire sensor cable

Jumpers W2 and W3 establish the correct shunt calibration connections for 4-wire and 8-wire sensor cables. The length of the sensor cable determines which type of cable is used. Short cables are typically 4-wire cables while long cables are typically 8-wire cables.

- Jumper W2 selects a 4- or 8-wire transducer for positive feedback.
- Jumper W3 selects a 4- or 8-wire transducer for negative feedback.
- The setting of jumper W8 (single ended excitation enable) may affect your choices for these jumpers (W2 and W3).

Note *+/– excitation (–excitation is standard). See R33 or XDCR ID-W1.*



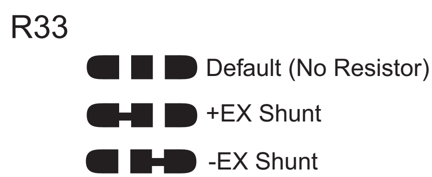
Excitation sense

Jumpers W5 and W7 select the local (on board) or remote (through a cable) excitation sensor connection.

- The local selection is used with 4-wire transducer connections.
- The remote selection is used with 8-wire transducer connections.
- Jumper W7 configures the + excitation signal.
- Jumper W5 configures the – excitation signal.
- Both jumpers should be set for the same configuration.

±Shunt cal

The shunt calibration resistor can be installed on the Full Range Digital Universal Conditioner module, or, in the transducer ID module. R33 assigns a positive or negative excitation to the shunt calibration resistor if installed on the Full Range Digital Universal Conditioner module (not the transducer ID module).

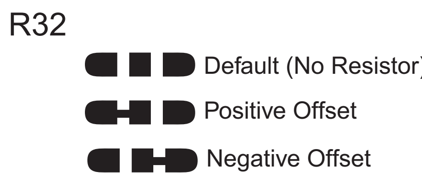


Single ended excitation

Jumper W8 connects -EX to ground for situations requiring single-ended excitation.

Bridge balance

R32 changes the offset of the bridge balance circuit. If the zero offset is too large when the sensor bridge is balanced, you should add an appropriately sized resistor.



Sensor Cables

A typical system is provided with a standard set of sensor cables as specified on the System Cable/Jumper Plug 493 Package Selection drawing (PN 700-000-656). Refer to this drawing for the most current part numbers. Standard sensor cables do not have ID modules.

Sensor cables with an ID module built into them are available as an option. Sensor cables with ID modules use a system cable to bridge the sensor cable to the appropriate connector on the rear panel of the chassis.

Specifications

- 15 contact type D male EMI connector
- Backshell–EMI metallized plastic
- Cable type–For all applications including CE EMC Compliance, use MTS cable material 505301-01 (two 22 AWG twisted pairs with inner and outer braided shield for the excitation and feedback signals, plus a twisted quad for the ID signals, and a single wire for the shunt calibration signal). Shield connections can vary from sensor to sensor.
- If purchased as an option, each sensor includes one cable with a transducer ID module and a system extension cable. A system cable is required between the transducer ID cable and the 493.10 Chassis.

Sensor Cable Part Numbers

Sensor cables without ID Module

See the System Cable/Jumper Plug 493 Package Selection drawing (PN 700-000-656) for the most current sensor cable part numbers.

Cable Description		Cable	Module Connector
ADT	**120º**	562348-XX	493.40 J4–J7
	300º	562531-XX	493.40 J4–J7
Extensometer 633 capacitive		516495-XX	493.40 J4–J7
Force Transducer w/PT connector		464402-XX	493.40 J4–J7
	w/MS connector	464406-XX	493.40 J4–J7
	w/PC	562529-XX	493.40 J4–J7
LVDT		464403-XX	493.40 J4–J7
ΔP control		479276-XX	493.40 J4–J7
Pressure Control (Sensotec)		562530-XX	493.40 J4–J7
Strain	**w/Amphenol connector**	562336-XX	493.40 J4–J7
	w/PT connector	501200-XX	493.40 J4–J7
Temposonics		491532-XX	493.40 J4–J7
Temposonics II (low power conditioner)		562532-XX	493.40 J4–J7
Temposonics III		563167-XX	493.40 J4–J7
RVDT w/MS connector		512028-XX	493.40 J4–J7

Sensors

Sensor cables with ID Module

See the System Cable/Jumper Plug 493 Package Selection drawing (PN 700-000-656) for the most sensor cable current part numbers.

Each sensor includes a cable with an ID module built into it. Use a system cable to bridge the sensor cable to the rear panel of the controller chassis.

Cable Description	ID Module w/Cable	System Cable[1]	Module Connector
ADT 120°	525435-XX	561258-XX	493.40 J4–J7
300°	524436-XX	561259-XX	493.40 J4–J7
Extensometer 633 capacitive	525434-XX	525443-XX	493.40 J4–J7
Force Transducer w/PT connector	525425-XX	525442-XX	493.40 J4–J7
w/PC connector	525426-XX	525442-XX	493.40 J4–J7
w/MS connector	525427-XX	525442-XX	493.40 J4–J7
LVDT	525431-XX	525442-XX	493.40 J4–J7
ΔP control	525432-XX	525442-XX	493.40 J4–J7
Pressure Control (Sensotec)	525433-XX	525442-XX	493.40 J4–J7
Strain w/Amphenol connector	525429-XX	525442-XX	493.40 J4–J7
w/PT connector	525430-XX	525442-XX	493.40 J4–J7
Temposonics	525437-XX	561260-XX	493.40 J4–J7
Temposonics II (low power conditioner)	525438-XX	525442-XX	493.40 J4–J7
RVDT w/MS connector	527508-XX	525442-XX	493.40 J4–J7

1. -XX specifies cable length. –01 through –09 represent 10–50 ft. in 5 ft. increments. Higher numbers represent custom cable lengths.

Sensors

Shunt Calibration

You can verify the calibration accuracy of a DC sensor/conditioner pair through shunt calibration. Shunt calibration works by shunting a precision resistor across one arm of the sensor's Wheatstone bridge. The resulting imbalance provides a reference value, which is provided in the calibration data sheet provided with the sensor.

A current shunt calibration value, taken before a test, should be compared to the shunt calibration reference value recorded when the sensor was last calibrated. If the reference value and the current value differ too greatly, the sensor/conditioner pair should be recalibrated to establish a new shunt reference value.

Significant variations between current and reference values may occur if the excitation voltage has drifted, or the sensor has been damaged or has changed if some other way. It is possible to adjust excitation to compensate for small to moderate changes in the shunt calibration value.

When to use shunt calibration

You should perform a shunt calibration (establish a new shunt reference value) when the following occur:

- You start a new test.
- You move a sensor to a different DC conditioner.
- You swap a DC conditioner module.
- You recalibrate a DC sensor.
- You change the sensor cable (resistance may differ).

Note *Shunt calibration can not be used to compensate for different length cables.*

Note *You cannot check shunt calibration of a sensor being used with the active control mode when hydraulic pressure is on.*

Note *Shunt calibration does not compensate for changes in the sensor sensitivity over time.*

How to perform a shunt calibration

Each resistive bridge type transducer (DC sensor) uses a shunt resistor to check the calibration accuracy of the sensor/conditioner combination. Each DC conditioner supports a shunt resistor.

Perform a shunt calibration to establish a new shunt reference value for a DC sensor/conditioner pair as follows:

1. Turn off hydraulic power
2. Remove the load standard.
3. Turn on hydraulic power.
4. Zero the DC sensor output.

   Adjust the **Manual Cmd** slider on the **Manual Command** window for a 0 kN output. The sensor output must be 0.000 kN for a proper shunt calibration.
5. Change the control mode.

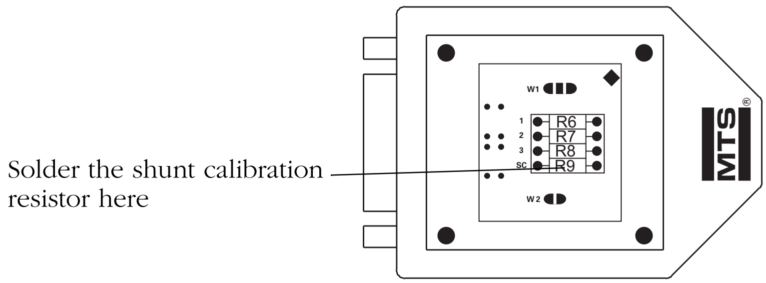
   Change **Control mode** on the **Manual Command** window to a **Displacement** control mode. Shunt calibration cannot be performed on a sensor when it is in control of the servo loop.
6. Determine the shunt calibration resistor from the following table:

Bridge Resistance	Sensitivity	Range (% Full Scale)	Resistor Value
350 Ω	**2 mV/V**	**100%** **50%** **20%** **10%**	**49.9 k** **100 k** **249 k** **499 k**
350 Ω	**1 mV/V**	**100%** **50%** **20%** **10%**	**100 k** **200 k** **499 k** **1000 k**
700 Ω	**2 mV/V**	**100%** **50%** **20%** **10%**	**100 k** **200 k** **499 k** **1000 k**
700 Ω	**1 mV/V**	**100%** **50%** **20%** **10%**	**200 k** **402 k** **1000 k** **2000 k**

Sensors

7. If you have sensor cables with optional transducer ID modules, complete the following procedure. If not, proceed to Step 8.

   Install the shunt calibration resistor into the **R9** location of the sensor ID module. The sensor identification cartridge is molded into the sensor cable.



8. If you do not have transducer ID modules on your sensor cables, install the shunt calibration resistor as follows:

   A. Select the appropriate shunt calibration resistor.

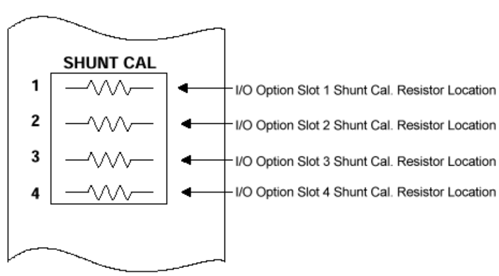
   B. Bend the resistor leads 90° for a 0.3 inch separation.

   C. Cut the resistor leads 0.12 inch from the bend.

   D. Insert the resistor into the connector solder cups and solder.

   E. Complete and attach a shunt calibration label as specified on the 493.40/41 Carrier I/O Shunt Calibration Kit (MTS PN 100-028-185).

   F. Install the shunt calibration resistor/connector assembly into the appropriate **SHUNT CAL** connector slot on the front panel of the appropriate I/O Carrier Module.



Sensors

9. Verify that force is still zero.

   While it is unlikely, it is possible for the force signal to change when the control mode changes. If it does, click **Auto Offset** on the **Offset/Zero** tab (**Inputs** panel) to zero the force output.

10. Perform a shunt calibration.

    Refer to “How to Perform a Shunt Calibration” in Chapter 3, Station Manager of the *Model 793.00 System Software* manual for a detailed procedure.

Shunt Calibration/Bridge Completion

On a typical system, shunt calibration and bridge completion resistor installation is completed on the I/O Carrier module.

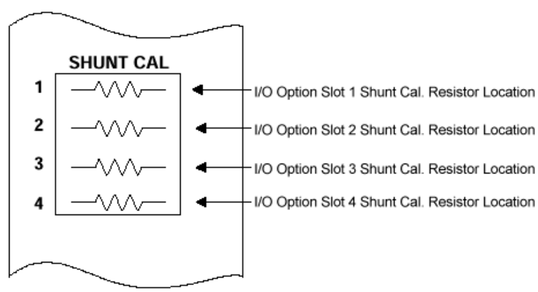
If you have purchased optional sensor cables with transducer ID modules, shunt calibration and bridge resistors are installed on these modules.

I/O Carrier Module

Shunt calibration connector

The I/O Carrier module has a shunt calibration connector on its front panel that allows up to four shunt resistors (1 per slot) to be plugged in. The **SHUNT CAL** connector is labeled to indicate which slot the shunt calibration resistor is tied to.

Each shunt calibration resistor is soldered to a 2-pin holder (MTS part number 114338-26). This holder plugs into the front panel connector shown below. Refer to the 493.40/41 Carrier I/O Shunt Calibration Kit (MTS part number 100-028-185) for more detailed information on kit components and installation.

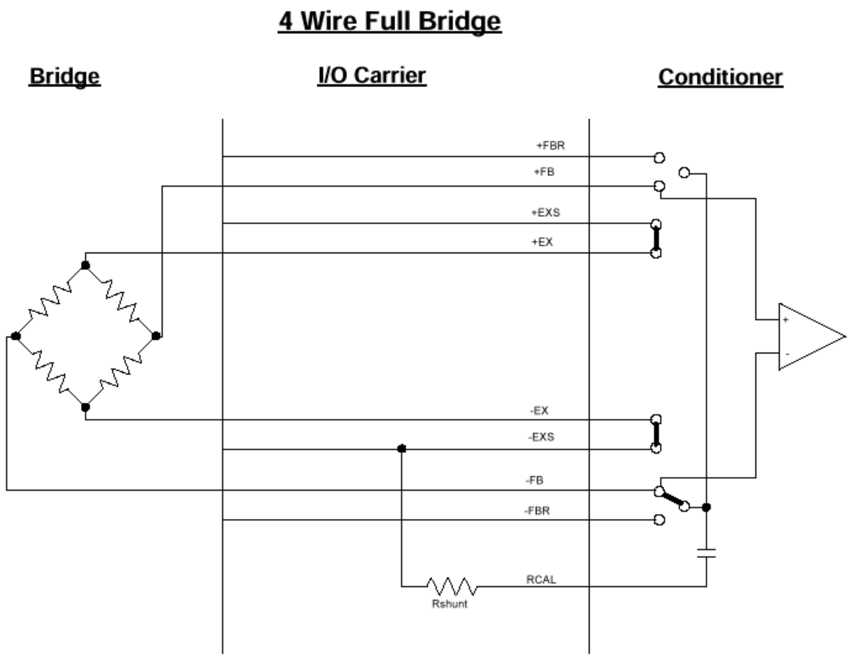


Sensors

Bridge completion circuits

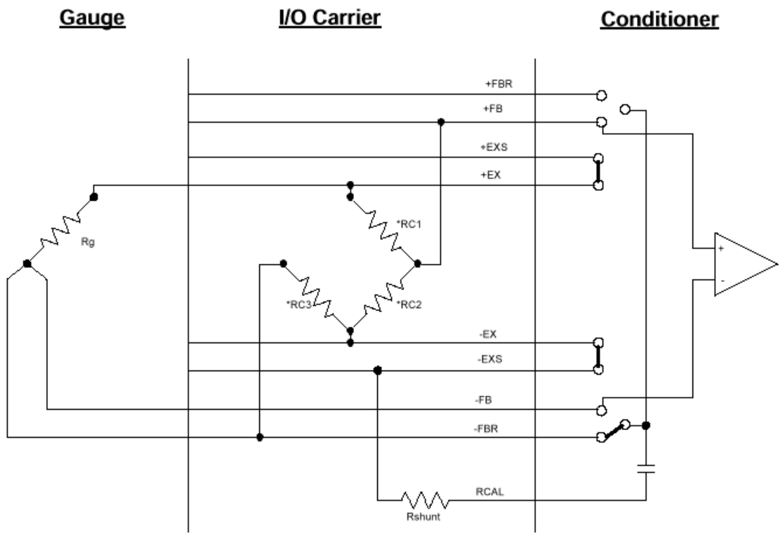
Each of the four I/O option card slots on the I/O Carrier module provides support for up to three bridge completion resistors as well as a shunt calibration resistor. The bridge completion resistors can be installed into sockets on the I/O Carrier printed wiring board. The shunt calibration resistor sockets are accessible from the I/O Carrier front panel.

The following figures show three typical bridge configurations for a DC conditioner installed on an I/O Carrier module.

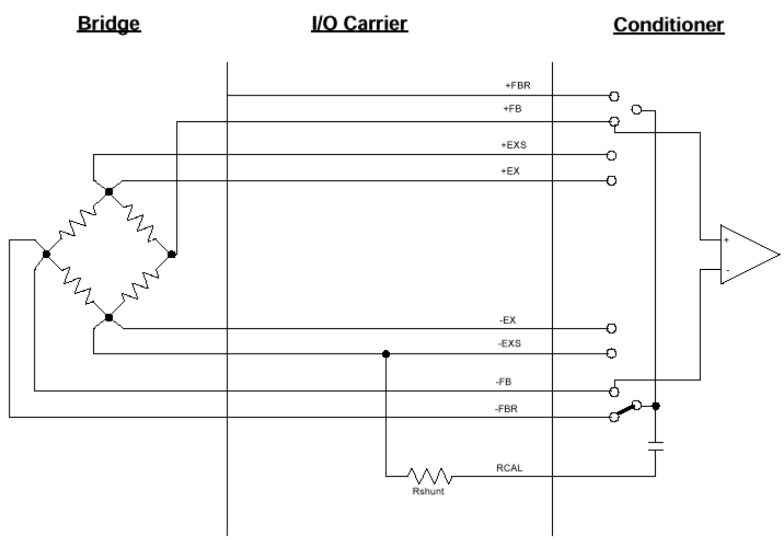


Sensors

3 Wire Quarter Bridge



7 Wire Full Bridge



Transducer Identification Modules

Transducer ID modules (located at the end of the sensor cable) are optional components that can store sensor calibration information just like a sensor calibration file. Since the calibration information stays with the sensors, transducer ID modules make it easier to change sensors.

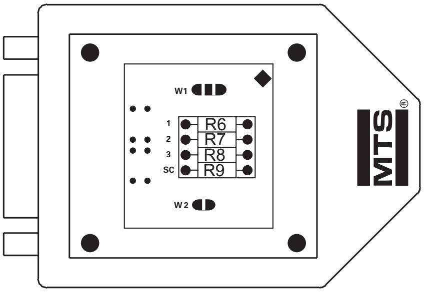
Calibration information can be stored in the transducer ID EEPROM or in a sensor calibration file. When you load a station that does not have a sensor file assigned to one or more of its signals, by default, the system software looks for calibration information in the transducer ID. See "How to Save Data to an ID Module" on page 144.

The molded ID module has a removable cover and includes provisions for:

- A shunt calibration resistor
- Up to three bridge completion resistors
- A transducer ID circuit card

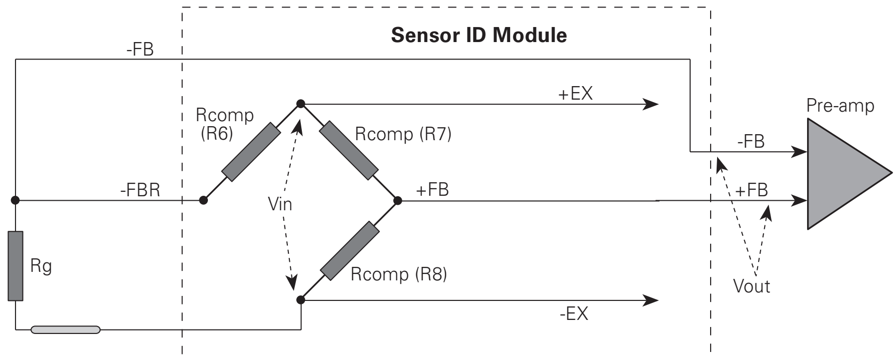
The circuit card has the bridge completion and shunt calibration resistors on one side, and the transducer ID circuit on the other.

- R6, R7, and R8 are the bridge completion resistors.
- R9 is the shunt calibration resistor.



The following is the schematic diagram of the bridge balance and bridge completion circuit.

Sensors



How to Assign a Sensor with an ID Module

Refer to “How to Assign a Sensor with a Transducer ID Module” in Chapter 3, Station Manager of the *Model 793.00 System Software* manual for a detailed procedure.

How to Save Data to an ID Module

Refer to “How to Save Data to a Transducer ID Module” in Chapter 3, Station Manager of the *Model 793.00 System Software* manual for a detailed procedure.

Chapter 6
Calibration

This chapter describes how to calibrate the sensors connected to your system. All sensors require calibration to ensure that their outputs accurately represent the physical condition they sense (e.g., force or displacement). When you calibrate a sensor you are calibrating the test system to properly interpret the sensor signal.

Sensors included with your test system are usually factory-calibrated, and the corresponding sensor calibration files are included with your system software. If you change a sensor or add a new sensor to your system, you must calibrate the new sensor/conditioner pair against a standard to ensure the sensor's accuracy.

You must calibrate all sensors before they can be used to support control modes or auxiliary data channels.

Contents

Prerequisite

You must have a Station Builder configuration file that includes the sensor(s) you wish to calibrate.

Initial calibration

If you are calibrating a sensor for the first time, you may find it necessary to:

- Perform an initial tuning of the sensor channel before calibration.
- Perform the procedure twice.

Abbreviated procedures

The abbreviated procedure provides an overview of the calibration procedure for those who are experienced at calibrating sensors. The abbreviated procedure lists the tasks and steps of the calibration procedure. Each task and step includes the page number of the detailed procedure where the task/step is described.

Detailed procedures

The detailed procedures follow the abbreviated procedures. They provide an enhanced sequence of the calibration procedure for those who are inexperienced at calibrating sensors. Each detailed procedure is a step-by-step procedure arranged by tasks. Each task is a group of detailed steps that accomplish a portion of the procedure. Some steps include examples or helpful information.

Some tasks refer to more detailed procedures.

Before You Begin

Before you start sensor calibration, *be sure* the following are true:

- The sensors are properly connected to the controller (see "Typical Cabling" on page 38).
- A station configuration file has been created that includes the hardware resources associated with the sensors you want to calibrate.
- The Station Manager program is running and the appropriate station configuration file is open.
- You have completed an initial, nominal tuning of the sensor channel you are calibrating. This is especially important if you have not calibrated the sensor before.
- The hydraulics are warmed up (see System warm-up below).
- **Gain** is set to 1 on the **Drive** panel **Conditioner** tab (3-stage servovalves only).
- You know your signal polarity (see Signal polarity below).

System warm-up

Be sure that both the hydraulic fluid and the servovalve are at operating temperature before calibration. Remove any specimen and run the system in displacement control for at least 30 minutes using a 80% full-scale length command at about 0.1 Hz.

Refer to "How to Warm Up the System Hydraulics" in Chapter 5, Tuning of the *Model 793.00 System Software* manual for a detailed procedure.

Signal polarity

Some test systems are configured to extend the actuator in response to a positive command, while other test systems are configured to retract the actuator in response to a positive command. Conditioner polarity determines feedback polarity.

You *must know* how your test system is configured so you can determine the appropriate polarity for the values used in this chapter. The valve polarity is established first (see "Setting the Servovalve Polarity" on page 115).

Full-range vs. Multi-range conditioners

Consider the following differences when calibrating sensors that use full-range conditioners, such as the 493.25 DUC, instead of multi-range conditioners:

- Full-range conditioners allow you to set up a linearized data table for a gain/linearization calibration of a sensor. See “How to Create a Sensor File” in Chapter 3, Station Manager of the *Model 793.00 System Software* manual for detailed information.
- When using linearized data, you must retain copies of the initial calibration report (containing non-linearized data) and the calibration report after applying linearization.
- When calibrating sensors that use a full-range conditioner, the **Electrical Zero Lock** must be checked on the **Offset/Zero** tab of the **Inputs** panel. Readjustment of electrical zero after calibration will change the point at which linearization takes place, disturbing other calibration settings.

Calibrating an LVDT

An LVDT is calibrated with a dial indicator or some other displacement measuring device. Displacement is usually calibrated such that the maximum extension and retraction represent ±100% of the full-scale capacity of the LVDT, with mid-displacement set at zero. Displacement can also be calibrated to any range within the full-scale capacity of the sensor. Also, ranges do not have to be centered on zero.

Prerequisites

Be sure the items described in "Before You Begin" on page 147 are true. An LVDT requires a digital universal conditioner (DUC) in AC mode to process the feedback signal. You must know which conditioner module is connected to the LVDT.

Note *If you are recalibrating a sensor, use the existing calibration values as a starting point.*

What you will need

You will need a dial indicator gage (or for longer displacements a measuring device such as a long ruler, laser, or optical detector) to calibrate an LVDT. All calibration tools should also be calibrated to an industry standard.

Important Notes

- During calibration, **Manual Offset** should always be set to zero.
- When calibrating sensors that use a full-range conditioner (e.g., 493.25 DUC), ensure that **Electrical Zero Lock** is checked on the **Offset/Zero** tab of the **Inputs** panel.
- After completing LVDT calibration, **do not change the electrical zero adjustment**. Readjustment of electrical zero after calibration will change the point at which linearization takes place, disturbing other calibration settings (especially delta k).

Pre-calibration tuning

Use the following procedure for initial tuning of the LVDT sensor channel prior to calibration. Pre-tuning is especially important if the LVDT has never been calibrated.

1. On the **Station Manager** toolbar, select **Calibration** in the User Level access box.
2. From the **Display** menu on the **Station Manager** window, select **Station Setup** to display the **Station Setup** window.
3. In the **Station Setup** window navigation pane, select the displacement channel you want to tune.
4. From the **Display** menu on the **Station Manager** window, select **Meters**, and then set up to monitor displacement feedback.
5. Click the **Channel Input Signals** icon to open the **Inputs** panel, and then click the **Calibration** tab.
6. On the **Inputs** panel, enter **Fullscale Min/Max** values that conform with your sensor specifications.

   Typically, you should set the fullscale min/max values according to the dynamic stroke rating of your actuator. The **DYN STROKE** rating is usually printed on a nameplate on the side of the actuator. For example, if the dynamic stroke rating of your actuator is 102 mm, you should set your full-scale min to -51 mm and your full-scale max to +51 mm.
7. Set **Excitation** to 10 volts.
8. Adjust **Post-amp Gain** for a 5 volt readout on the meter.
9. Adjust **Phase** for the maximum output voltage on the meter.
10. Adjust **Post-amp Gain** for a 9.5 volt readout on the meter.
11. Check to ensure that the polarity of the servovalve signal set correctly. See “Setting the Servovalve Polarity” on page 115.

    A. Ensure that the correct displacement control channel is selected in the navigation panel.

    B. Click the **Channel Drive** icon to open the **Channel Drive** panel, and then click the **Valve** tab.

    C. Check the valve polarity setting. If you do not know what polarity to use for your servovalve, click **Normal** (default).

12. From **Station Setup**, click the **Channel Tuning** icon, and then click the **Adjustments** tab.

13. Set **P Gain** to 0.5

14. On the **Station Controls** panel perform the following setup:

    A. Click the **Manual Command** button to open the **Manual Command** window.

    B. In the **Channel** selection box, ensure that the desired control channel is selected.

    C. In the **Control Mode** selection box, ensure that the displacement control mode is selected.

    D. Click on the **Enable Manual Command** check box to enable manual command.

    E. Ensure that the **Master Span** is set for 100%.

    F. If the **Interlock** indicator is lit, determine the cause, correct it, and then click **Reset**.

    G. If it lights again, you will need to determine the cause of the interlock and correct it before proceeding.

    H. In the power selection box, click the **Power Low** button, and then **Power High** for the appropriate hydraulic service manifold (HSM).

15. Check the movement of the actuator.

    On the **Manual Command** window, increase the **Manual Cmd** adjustment for a positive command.

Note *The following conditions assume you want a positive command to extend the actuator.*

Actuator fully retracted or extended

- If the actuator is fully extended and applying a negative **Manual Cmd** does not retract it, zero the command, remove hydraulic pressure, and change the servovalve polarity. Then retry this test. If it still does not move, return to Step 13 and increase the gain setting.

- If the actuator is fully retracted and applying a positive **Manual Cmd** does not extend it, zero the command, remove hydraulic pressure, and change the servovalve polarity. Then retry this test. If it still does not move, return to Step 13 and increase the gain setting.

Actuator not fully retracted or extended

- If the actuator does not move at all, return to Step 13 and increase the gain setting.
- If the actuator extends, the servovalve polarity is correct.
- If the actuator retracts, the servovalve polarity must be reversed. Change the **Polarity** setting (on the **Valve** tab of the **Drive** panel) from **Normal** to **Inverted** or vice versa.

16. In the **Station Manager** navigation pane, click the **Function Generator** icon to display the **Function Generator** panel.

17. Set up the **Function Generator** with the following settings:

CONTROL	SETTING
Control Channel	The control channel you are tuning.
Control Mode	Displacement
Adaptive Compensator	None
Target Setpoint	0
Amplitude	5% of full scale
Frequency	1 Hz
Wave Shape	square

18. Set up the **Station Manager** window's **Scope** to display the channel's command and feedback signals.

    A. In the **Station Manager** toolbar, click the **Scope** button to display the **Scope** window.

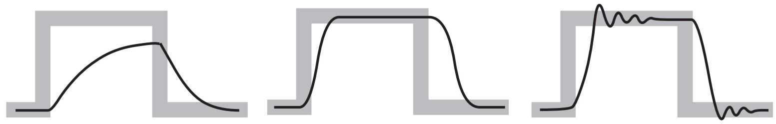
    B. Set up the **Scope** window to display the channel's command and feedback signals.

19. In the **Station Controls** panel, click **Program Run** to start the function generator.

20. On the **Tuning** panel **Adjustments** tab, increase **P Gain** while observing the displacement feedback signal.

21. Initial tuning is achieved when the displacement feedback signal approximates the square wave as shown below:

The tuning command is shown as a gray square waveform, and the black waveform is the sensor feedback



Gain Too Low | Optimum Gain | Gain Too High

Abbreviated Procedure

Online readers *All procedure entries are hypertext links. Click on any entry to jump to the corresponding page.*

The following abbreviated procedure outlines a displacement sensor (LVDT) calibration process. More detailed calibration information is available on the pages listed.

Task 1 Get things ready

Perform the following before you start sensor calibration.

1. Locate relevant documentation.
   - You need information about the sensor such as the serial number, model number, excitation voltage, displacement, etc. This information can be found on the appropriate Calibration Data sheet included with your system, or the Final Inspection card included with all MTS sensors.
   - You need calibration identification numbers for any calibration tools that will be used for this calibration procedure (e.g., the dial indicator used for LVDT calibration). The calibration information is usually on a sticker attached to the equipment.
   - You need the appropriate DUC Conditioner serial number.
2. Open a station configuration file.

   You need a station configuration file that includes a control channel with a control mode that uses the sensor you intend to calibrate.

   Also, to monitor the sensor output signal with an external DVM, ensure that you have allocated an analog output resource (readout channel) in the Station Builder program.

   On the **File** menu, select **Open Station**, and then open the appropriate configuration file on the **Open Station** window.
3. Enter the Calibration password.

   You must access the Calibration user level before you can perform any of the calibration procedures.

4. Set up a signal monitor.

Note *You cannot monitor the output of a new sensor until a sensor calibration file has been created and the sensor assigned to an input signal.*

You will be monitoring the sensor output when making adjustments throughout this procedure. You can monitor the sensor output in the same units that you are using for the calibration.

You can use an external DVM to monitor sensor output from a BNC connector on the Analog Out panel located on your controller chassis.

If you do not have an Analog Out panel, use the **Meters** window or **Station Signals** panel to monitor sensor output. On the Station Manager **Display** menu, select **Station Setup**. In the navigation pane, select **Station Signals** to display the **Station Signals** panel to monitor current values for user-defined signals.

For more information on using the **Station Signals** panel, refer to "About the Station Signals Panel" in Chapter 3, Station Manager of the *Model 793.00 System Software* manual.

Task 2 Create a calibration file

This task creates a sensor calibration file and sets up your ranges. A typical complement of ranges could be: 100%, 50%, 20%, and 10% of full scale. You may create ranges for any percentage of full scale.

Note *Some systems do not provide or require multiple ranges, such as those using full-range conditioners (e.g., Model 493.25 DUC module). In this case, only one range is used (typically 100%).*

See “How to Create a Sensor File” in Chapter 3, Station Manager of the *Model 793.00 System Software* manual for a detailed procedure.

Conditioner calibration values

For LVDT calibration, set the following initial conditioner calibration values:

CONTROL	SETTING
Polarity	Normal
Pre-Amp Gain	1.0
Post-Amp Gain	1.5
Excitation	10 volts
Phase	45°
Delta K	1
Zero	0

Task 3 Assign a calibration file

This task links a sensor calibration file (created in **Task 2**) to a hardware resource. The purpose for this is to select one of the sensor ranges for the input signal definition.

See "How to Assign a Sensor File" in Chapter 3, Station Manager of the *Model 793.00 System Software* manual for a detailed procedure.

Task 4 Turn on hydraulic pressure

This task activates the hydraulic pressure.

WARNING

Do not place any part of your body in the path of a moving actuator.

A crush zone exists between the actuator and any equipment in the path of its movement. Immediate and unexpected actuator response is possible when you apply hydraulic pressure to your system.

Stay clear of the actuators when applying hydraulic pressure.

1. On the Station Manager **Display** menu, select **Station Setup**.
2. In the **Station Setup** navigation pane, locate and select the channel associated with the sensor signal you are calibrating.
3. In the **Station Controls** panel's toolbar, click the **Manual Command** button to display the **Manual Command** window.

   In the **Manual Command** window:

   A. Select the **Channel** associated with the sensor signal you are calibrating.

   B. For the **Control Mode**, select the displacement associated with the sensor signal you are calibrating.

   C. Click **Enable Manual Command**.
4. On the **Station Controls** panel, ensure the **Master Span** is set for 100%.
5. If the **Interlock** indicator is lit, click **Reset**. If the indicator lights again, you must determine the cause and correct it before proceeding.
6. In the power selection box, click the **Power Low** button, and then **Power High** for the HPU. If an HPU is not listed, start the HPU at the pump.

Note *The HPU can be configured for "first on." If this is the case, start the appropriate HSM.*

7. If an HSM is present, click the **Power Low** button, and then **Power High** for the appropriate HSM.

Task 5 Verify the conditioner polarity

This task checks the polarity of the conditioner. Different types of test systems are configured with different conditioner polarities. The polarity of the conditioner, the polarity of the valve driver, and the orientation of system cabling all play a role in controlling the actuator and determining how signals are displayed. This procedure assumes the servovalve polarity is set to **Normal** on the Station Setup **Drive** panel **Valve** tab.

1. Check the sensor connection.

   Be sure the displacement sensor is properly connected.

2. In the **Station Controls** toolbar, click the **Manual Command** button to display the **Manual Command** window.

   In the **Manual Command** window:

   A. Select the appropriate **Channel**.

   B. For the **Control Mode**, select the displacement associated with the LVDT signal you are calibrating.

   C. Click **Enable Manual Command**.

3. Move the **Manual Cmd** slider to apply a positive command (extend the actuator).

4. Monitor the displacement feedback.

   On the **Station Signals** panel, monitor the appropriate displacement feedback signal. If the signal value is positive for actuator extension, the conditioner polarity is correct. If desired, you can change the conditioner polarity to make the signal value negative for actuator extension.

Note *The polarity setting should be the same when calibrating additional ranges for the same sensor.*

Calibration

Task 6 Set the phase

This task determines the proper phase adjustment. The phase adjustment matches the phase of the AC feedback signal to the 10 kHz demodulation signal.

1. Apply a manual command to fully retract the actuator.

   Slide the **Manual Cmd** control on the **Manual Command** window to fully retract the actuator.

2. Remove hydraulic pressure.

   Phase adjustments are best performed in a full-scale range. If the actuator is not fully retracted, disable hydraulic pressure.

3. Adjust phase for the maximum conditioner output.

   On the **Station Signals** panel, monitor the appropriate AC conditioner feedback signal. Adjust the **Phase** control on the **Calibration** tab to achieve a maximum value.

Note *When adjusting phase, the LVDT feedback may exceed 10 volts. You may need to adjust the **Gain** slider (on the Station Setup Drive panel) for a lower conditioner gain before continuing phase adjustment.*

Task 7 Set the zero and offset

Establishing zero requires the actuator to be set at mid-displacement when you calibrate the LVDT for equal amounts of actuator extension and retraction.

Suppose you have an actuator with ±10 cm displacement—which actually has a 20 cm displacement. Setting zero at mid-displacement produces a displacement of ±10 cm (this is the most common approach). However, you can set zero anywhere within the full scale of the sensor, such as with the actuator fully extended or retracted to produce a displacement range of 0 mm - 20 mm.

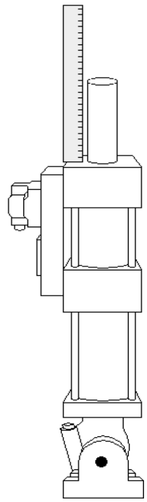
Before beginning, be sure the following are true:

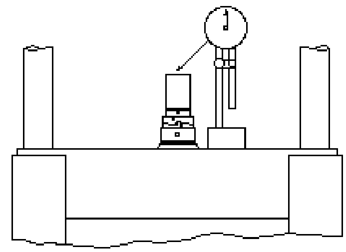
- The **Fine Zero** adjustment on the **Calibration** tab is 0.
- The **Manual Offset** on the **Offset/Zero** tab is 0.
- The **Electrical Zero** adjustment on the **Offset/Zero** tab is 0.

1. Mount the displacement measuring device.

   Mount the measuring device to measure the distance between the end of the actuator's piston rod and a stationary point such as the actuator's upper endcap. There are a variety of ways to measure actuator displacement:

   - Dial Indicator
   - Tape Measure/Ruler
   - Optical Detector
   - Encoder





- You may need to place the dial indicator on a block to measure the mid-displacement position.
- Be sure to zero the dial indicator after you position it properly.

2. In the **Station Controls** panel's toolbar, click the **Manual Command** button to display the **Manual Command** window.

   In the **Manual Command** window:

   A. Select the appropriate **Channel** associated with the LVDT signal you are calibrating.

   B. For the **Control Mode**, select **Displacement**.

   C. Click **Enable Manual Command**.

3. Evaluate the mid-displacement position for the actuator.

   A. Move the **Manual Cmd** slider to apply a positive command (extend the actuator).

   B. Adjust the **Manual Cmd** slider to fully extend the actuator and note the displacement signal value in the **Station Signals** panel.

   C. Adjust the **Manual Cmd** slider to fully retract the actuator and note the displacement signal value in the **Station Signals** panel.

   The noted signal values should be within 1% of each other.

If not, you can evaluate the following procedures to establish the zero reference:

- Use the **Fine Zero** adjustment on the **Calibration** tab to shift the sensor conditioner's zero reference position.

Note *Some conditioners have two zero adjustments (coarse and fine). Try to calibrate zero using only the **Fine Zero** control whenever possible. Using the **Coarse Zero** control affects the signal before the post amp stage of the conditioner and may require additional **Gain** adjustments.*

- In some cases, a mechanical adjustment may be necessary to center the LVDT (for instructions, see the actuator product manual).

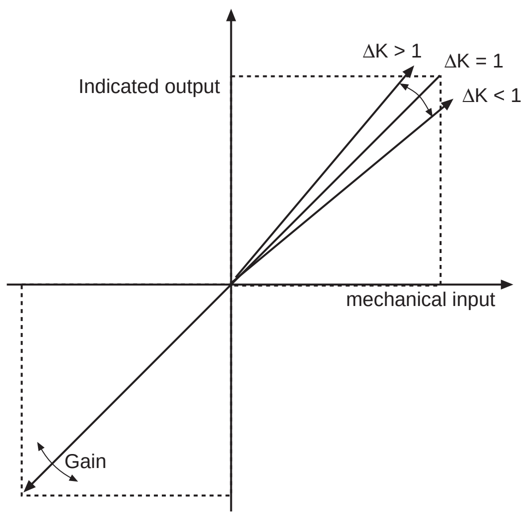
Task 8 Gain/Delta K Calibration

If you are using **Gain/Delta-K** for your calibration type, complete the following procedure. If not, complete **Task 9 Gain/Linearization Calibration** on page 169

Calibrate actuator retraction

LVDTs can be calibrated so that a positive output represents actuator extension and a negative output represents actuator retraction, or vice versa.

You calibrate the negative side of the output with gain and the positive side of the output with Delta K.



Delta K compensates for differences in symmetry between the positive and negative outputs.

You should calibrate actuator extension at 80% of full scale for each range.

Gain controls

Pre-Amp gain is a selectable gain amplifier with predefined values. Since changes in **Pre-Amp** gain can cause spikes in the feedback signal, **Pre-Amp** gain can only be adjusted when hydraulics are off.

Post-Amp gain is a finer, operator-defined gain control that can be adjusted when hydraulics are on.

The **Total** gain value is calculated by multiplying the **Pre-Amp** and **Post-Amp** gain values. If the total desired gain amount is known (from a calibration sheet), you can enter the amount in the **Total** gain box and the software will calculate the **Pre-Amp** and **Post-Amp** gain values automatically.

When you are calibrating an AC conditioner, use the **Post-Amp** gain control to increase gain. If more gain is needed, you must disable hydraulics and increase the **Pre-Amp** gain. You can then turn on hydraulics and continue to adjust the **Post-Amp** gain slider.

Note *This procedure assumes a positive command extends the actuator and a negative command retracts the actuator. If not, use the opposite polarity for any values given.*

1. Select **Gain/Delta-K** for **Cal Type** on the **Calibration** tab of the **Inputs** panel.

2. Apply a retraction command that is 80% of the range's full scale.

   Do this by adjusting the **Manual Cmd** slider on the **Manual Command** window, then verify that the **Station Signals** panel reads what you applied with the slider. During the initial calibration and tuning of your system, it may require repeated adjustment for the two values to match.

Note *If the actuator response is sluggish and/or the signal value does not match the command, you will need to adjust the tuning of this control mode. Increase the proportional gain (**P Gain** on the **Adjustments** tab of the **Tuning** panel) to correct sluggish actuator movement. Increase the reset integration value (**I Gain**) to help the feedback match the command.*

   At this point, unless the conditioner is already in calibration, the actuator's physical retraction will not equal your commanded value. You will adjust gain in the next step so that the actuator's physical retraction and your commanded retraction match.

   Example: Suppose your actuator has a 100% retraction of -10 cm. In this step you would apply a -8 cm command, and even though the station signals would read -8 cm of feedback, the actuator may retract only -4 cm. This shows the conditioner/sensor pair are out of calibration.

3. Adjust gain to retract the actuator until it equals your retraction command.

   Adjust the **Post-Amp Gain** control on the **Calibration** tab until your dial indicator or other readout device shows that the actuator's physical retraction equals your retraction command.

4. If applicable, repeat steps 1 and 2 for all ranges.

 Example: Suppose you have an actuator with a full-scale capacity of ±10 cm and ranges of ±10 cm, ±5 cm, ±2 cm, and ±1 cm. In this case you would repeat this process and calibrate retraction at 80% of each range (-8 cm, -4 cm, -1.6 cm, and -0.8 cm).

Note *Some systems do not provide or require multiple ranges, such as those using full-range conditioners (e.g., Model 493.25 DUC module). In this case, only one range is used (typically 100%).*

Note *This procedure assumes a positive command extends the actuator and a negative command retracts the actuator. If not, use the opposite polarity for any values given.*

Calibrate actuator extension

5. Apply an extension command that is 80% of the range's full scale.

 Do this by adjusting the Manual Cmd slider on the Manual Command window, then verify that the Station Signals panel reads what you applied with the slider. During the initial calibration and tuning of your system, it may take repeated adjustment for the two values to match.

Note *If the actuator response is sluggish and/or the signal value does not match the command, you will need to adjust the tuning of this control mode. Increase the proportional gain (**P Gain** on the **Adjustments** tab of the **Tuning** panel) to correct sluggish actuator movement. Increase the reset integration value (**I Gain**) to help the feedback match the command.*

 At this point, unless the conditioner is already calibrated, the actuator's physical extension will not equal your commanded value. You will adjust Delta K in the next step so that the actuator's physical extension and your commanded extension match.

 Example: Suppose your actuator has a 100% extension of 10 cm. In this step you would apply a 8 cm command, and even though the station signals would read 8 cm of feedback, the actuator may extend only 4 cm. This shows the conditioner/sensor pair are out of calibration.

6. Adjust Delta K to extend the actuator until it equals your extension command.

 Adjust the **Delta K** slider on the **Calibration** tab until the dial indicator or other readout device shows that the actuator's physical extension equals your extension command.

7. If applicable, repeat steps 5 and 6 for all ranges.

   Example: Suppose you have an actuator with a full-scale capacity of ±10 cm and ranges of ±10 cm, ±5 cm, ±2 cm, and ±1 cm. In this case you would repeat this process and calibrate extension at 80% of each range (8 cm, 4 cm, 1.6 cm, and 0.8 cm).

Note *Some systems use full-range conditioners (e.g., Model 493.25 DUC module). In this case, only one range is used (typically 100%).*

Record data points

The accuracy tolerance of your data depends on the manufacturer of your sensor. Your sensor should include a calibration data sheet that shows the data point tolerance. Sensors from MTS include a sensor calibration data sheet that shows the data points as it was calibrated.

1. Record the data points for LVDT extension.

   A. Adjust the **Manual Cmd** slider to achieve zero command.

   B. Adjust the dial indicator for a zero reference.

   C. Adjust the **Manual Cmd** slider to 20% extension and record the dial indicator reading. Repeat this step for 40%, 60%, 80%, and 100% actuator extension.

2. Record the data points for LVDT retraction.

   A. Adjust the **Manual Cmd** slider to achieve zero command.

   B. Adjust the dial indicator for a zero reference.

   C. Adjust the **Manual Cmd** slider to 20% retraction and record the dial indicator reading. Repeat this step for 40%, 60%, 80%, and 100% actuator retraction.

Task 9 Gain/Linearization Calibration

If you are using **Gain/Linearization** for your calibration type, complete the following procedure. If not, complete **Task 8 Gain/Delta K Calibration** on page 165.

Important *Using linearization data requires specific conditioner zeroing practices. Ensure that **Electrical Zero Lock** on the **Offset/ Zero** menu is set to **Locked**. Adjusting electrical zero after calibration may invalidate linearization data.*

Important *Changing conditioner polarity after calibration may invalidate linearization data. If you need to change conditioner polarity (for example, when moving a sensor to a different test system), the sensor may need to be recalibrated.*

Initial LVDT calibration

For initial calibration of an LVDT complete the following procedure:

1. Select **Gain/Linearization** for **Cal Type** on the **Calibration** tab of the **Inputs** panel,
2. Apply a retraction command that is 80% of the range's full scale.

   A. Adjust the **Manual Cmd** slider on the **Manual Command** window for 80% of the full scale range.

   B. Use the **Station Signals** panel to verify that your LVDT displacement signal equals 80% of the full scale range.

   During the initial calibration and tuning of your system, it may require repeated adjustment for the retraction command and displacement values to match.

Note *If the actuator response is sluggish and/or the signal value does not match the command, you will need to adjust the tuning of this control mode. Increase the proportional gain (**P Gain** on the **Adjustments** tab of the **Tuning** panel) to correct sluggish actuator movement. Increase the reset integration value (**I Gain**) to help the feedback match the command.*

At this point, unless the conditioner is already in calibration, the actuator's physical retraction will not equal your commanded value. You will adjust gain in the next step so that the actuator's physical retraction and your commanded retraction match.

Example: Suppose your actuator has a 100% retraction of -10 cm. In this step you would apply a -8 cm command, and even though the station signals would read -8 cm of feedback, the actuator may retract only -4 cm. This shows the conditioner/sensor pair are out of calibration.

3. Adjust gain to retract the actuator until it equals your retraction command.

   Adjust the **Post-Amp Gain** control on the **Calibration** tab until your dial indicator or other readout device shows that the actuator's physical retraction equals your retraction command.

4. Apply an extension command that is 80% of the full scale range.

   A. Adjust the **Manual Cmd** slider for an extension command that is 80% of the full scale range.

   B. Verify that your LVDT displacement signal (feedback) is approximately equal to 80% of the full scale range.

5. Record dial indicator and conditioner feedback readings at predetermined retraction command points on the Linearization Data window.

Note *After shutting down system hydraulics, you will enter these recorded readings on the Linearization Data window.*

   A. Adjust the **Manual Cmd** slider for a 0% command.

   B. Record the dial indicator value for the 0% command.

   C. Enter the corresponding conditioner feedback reading in the **Conditioner** column at the appropriate row in the window.

   D. Adjust the **Manual Cmd** slider for a -2% retraction command.

   E. Record dial indicator value and conditioner feedback at the -2% row of your record sheet.

   F. Repeat steps D and E for other retraction commands (typically at -4, -6, -8, -10, -20, -40, -70, and -100 percent of full scale).

6. Record dial indicator and conditioner feedback readings at predetermined extension command points.

   A. Adjust the **Manual Cmd** slider for a +2% extension command.

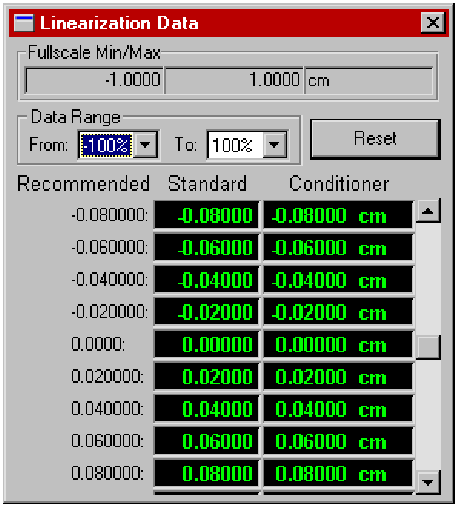
B. Record the dial indicator value and conditioner feedback at the +2% row of your record sheet.

C. Repeat steps A and B for other extension commands (typically at +4, +6, +8, +10, +20, +40, +70, and +100 percent of full scale)

7. Turn off system hydraulics.

8. On the Linearization Data window, enter the dial indicator and conditioner feedback readings for all command points previously recorded.

   Click **Linearization Data** on the **Calibration** tab to open the Linearization Data window.



9. Turn on system hydraulics.

LVDT recalibration

If the LVDT has been previously calibrated, use the following procedure:

1. Locate the calibration data sheet for the appropriate conditioner.
2. Turn off system hydraulics.
3. Click **Linearization Data** on the **Calibration** tab to open the Linearization Data window.

4. Transfer **Standard** and **Conditioner** data from the conditioner's calibration data sheet to corresponding data entries on the Linearization Data window.

5. Turn on system hydraulics.

6. Verify the linearization data.

   A. Adjust the **Manual Cmd** slider for each retraction and extension command point on the Linearization Data window.

   B. At each command point, verify both the dial indicator value (**Standard**) and its corresponding conditioner feedback value (**Conditioner**) with the corresponding values on the Calibration Data sheet

   If the data is valid: **Stop** this procedure.

   If the data is not valid: **Proceed** to the next step.

7. Click **Reset** on the Linearization Data window to return to default values.

8. Apply a retraction command that is 80% of the range's full scale.

   A. Adjust the **Manual Cmd** slider on the **Manual Command** window for 80% of the full scale range.

   B. Use the **Station Signals** panel to verify that your LVDT displacement signal equals 80% of the full scale range.

   During the initial calibration and tuning of your system, it may require repeated adjustment for the retraction command and displacement values to match.

Note *If the actuator response is sluggish and/or the displacement signal value does not match the command, you will need to adjust the tuning of this control mode. Increase the proportional gain (**P Gain** on the **Adjustments** tab of the **Tuning** panel) to correct sluggish actuator movement. Increase the reset integration value (**I Gain**) to help the feedback match the command.*

At this point, unless the conditioner is already in calibration, the actuator's physical retraction will not equal your commanded value. You will adjust gain in the next step so that the actuator's physical retraction and your commanded retraction match.

Example: Suppose your actuator has a 100% retraction of -10 cm. In this step you would apply a -8 cm command, and even though the station signals would read -8 cm of feedback, the actuator may retract only -4 cm. This shows the conditioner/sensor pair are out of calibration.

9. Adjust gain to retract the actuator until it equals your retraction command.

   Adjust the **Post-Amp Gain** control on the **Calibration** tab until your dial indicator or other readout device shows that the actuator's physical retraction equals your retraction command.

10. Apply an extension command that is 80% of the full scale range.

    A. Adjust the **Manual Cmd** slider for an extension command that is 80% of the full scale range.

    B. Verify that your LVDT displacement signal (feedback) is approximately equal to 80% of the full scale range.

11. Record dial indicator and conditioner feedback readings at predetermined retraction command points.

Note *After shutting down system hydraulics, you will enter these recorded readings on the Linearization Data window.*

    A. Adjust the **Manual Cmd** slider for a 0% command.

    B. Record the dial indicator value at 0% command.

    C. Record the corresponding conditioner feedback reading at the 0% row of your record sheet.

    D. Adjust the **Manual Cmd** slider for a -2% retraction command.

    E. Record the dial indicator and conditioner feedback values at the -2% row of your record sheet.

    F. Repeat steps D and E for other retraction commands (typically at -4, -6, -8, -10, -20, -40, -70, and -100 percent of full scale).

12. Record conditioner feedback readings at predetermined extension command points.

    A. Adjust the **Manual Cmd** slider for a +2% extension command.

    B. Record the dial indicator value and conditioner feedback at the -2% row of your record sheet

    C. Repeat steps A and B for other extension commands (typically at +4, +6, +8, +10, +20, +40, +70, and +100 percent of full scale).

13. Turn off system hydraulics.

14. On the Linearization Data window, enter the dial indicator and conditioner feedback values for all command points previously recorded on a separate sheet.

15. Turn on system hydraulics.

16. Verify linearization data.

    A. Adjust the **Manual Cmd** slider for each retraction and extension command point on the Linearization Data window.

    B. At each command point, verify both the dial indicator value (**Standard**) and its corresponding conditioner feedback value (**Conditioner**).

    C. Check validity before entering each pair of values on a new Calibration Data Sheet.

Task 10 Save the calibration

It is important that you save your sensor calibration values.

Click **Save** on the **Calibration** tab to save the current calibration values to the sensor calibration file.

Task 11 Calibrate additional ranges

This task describes how to calibrate additional ranges. Each sensor calibration file can have calibration data for four ranges. If you have a need for additional ranges, simply create another sensor calibration range.

- Use the calibration values from the previous range as a starting point.
- If you adjust the zero reference, it may affect the other ranges.

Note *Some systems do not provide or require multiple ranges, such as those using full-range conditioners (e.g., Model 493.25 DUC module). In this case, only one range is used (typically 100%).*

Adding a range

If the sensor calibration file must have additional ranges defined, perform the following:

1. On the **Tools** menu, select **Sensor File Editor**.
2. Open the sensor file for the sensor you have just calibrated.
3. Click **Add** under **Range Definition**.
4. Select the units for the range, and then enter the absolute value of the range.
5. Save the new range to the calibration file.
6. Calibrate the added range

Note *Ranges can also be added on the **Sensor** tab and calibrated on the **Calibration** tab.*

Calibrating a Force Sensor

A force sensor (also called a load cell) is calibrated with a load standard. It is calibrated such that the maximum compression and tension represent ±100% of the full-scale capacity of the force sensor, with zero force set at midcapacity.

Prerequisites

Be sure the items described in "Before You Begin" on page 147 are true. A force sensor requires a Digital Universal Conditioner (DUC) configured for the DC mode that processes a DC feedback signal. You must know which conditioner is connected to the sensor.

Initial calibration

If you are calibrating a sensor for the first time, you may find it necessary to:

- Perform an initial tuning of the sensor channel before calibration.
- Perform the procedure twice.

Recalibration

If you are recalibrating a sensor, use the existing calibration values as a starting point.

Important notes

- During calibration, **Manual Offset** should always be set to zero.
- When calibrating sensors that use a full-range conditioner (e.g., 493.25 DUC), ensure that **Electrical Zero Lock** is checked on the **Offset/Zero** tab of the **Inputs** panel.
- After completing force sensor calibration, **do not change the electrical zero adjustment**. Readjustment of electrical zero after calibration will change the point at which linearization takes place, disturbing other calibration settings (especially delta k).

What you will need

You will need the following items to calibrate a a force sensor. All calibration tools should also be calibrated to an industry standard.

- A load standard can be a calibrated force sensor with its own electronics or it can be a calibrated set of dead weights.

Note *This calibration procedure calibrates the DC conditioner for a force sensor of ±10 kN. You will need to adjust the procedure to accommodate your force sensor.*

- A DVM to monitor the output of the load standard.

Abbreviated Procedure

Online Readers *All procedure entries are hypertext links. Click on any entry to jump to the corresponding page.*

The following abbreviated procedure outlines a force sensor (load cell) calibration process. More detailed calibration information is available on the pages listed.

Task 1 Get things ready

Perform the following before you start sensor calibration.

1. Locate relevant documentation (e.g., sensor information, conditioner serial number, and calibration tool ID numbers)
2. Set up to monitor load standard output.
3. Open a station configuration file.

   You need a station configuration file that includes a control channel with a control mode that uses the sensor you intend to calibrate.
4. Enter the Calibration password.

   You must access the Calibration user level before you can perform any of the calibration procedures.
5. Set up a signal monitor.

Note *You cannot monitor the output of a new sensor until a sensor calibration file has been created and the sensor assigned to an input signal.*

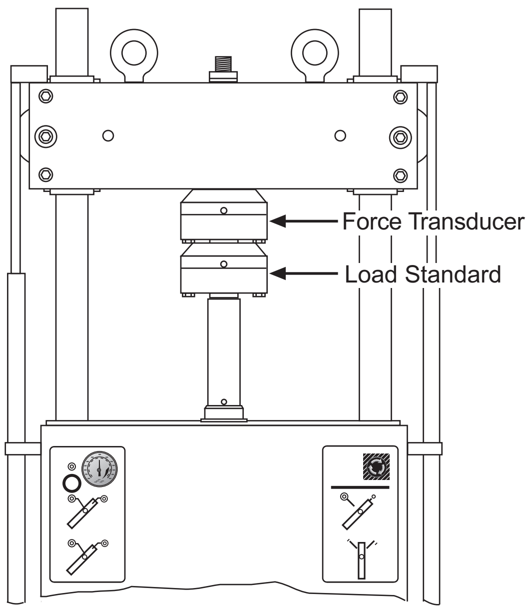
You will be monitoring the sensor output when making adjustments throughout this procedure. You can monitor the sensor output in the same units that you are using for the calibration.

6. Mount the force standard.

The illustration shows a load standard in-line with the force train coupled with the force sensor.

The load standard reacts like a stiff specimen. Be sure the gain settings (PID) for the control mode are appropriate.

If the control mode has not been tuned yet, use some default values. Then recalibrate the sensor after the initial tuning.



Task 2 Create a calibration file

This task creates a sensor calibration file and sets up any ranges you may want. A typical complement of ranges could be: 100%, 50%, 20%, and 10% of full scale. You can create ranges for any percentage of full scale.

Example: Suppose you have an actuator with a full-scale capacity of ±10 kN. You might create ranges for ±10 kN, ±5 kN, ±2.0 kN, and ±1.0 kN.

Note *Some systems do not provide or require multiple ranges, such as those using full-range conditioners (e.g., Model 493.25 DUC module). In this case, only one range is used (typically 100%).*

Note *Sensor calibration and range information can be edited on the* ***Sensor*** *tab, located on the* ***Station Setup*** *window* ***Inputs*** *panel.*

See "How to Create a Sensor File" in Chapter 3, Station Manager of the *Model 793.00 System Software* manual for a detailed procedure.

Conditioner calibration values

For force sensor calibration, set the following initial conditioner calibration values.

Control	Setting
Polarity	Normal
Pre-amp Gain	250 480 (for Model 493.25 conditioner)
Post-amp Gain	2 1 (for Model 493.25 conditioner)
Total Gain	500
Excitation	10 volts
Fine Zero	0
Zero/Balance	0
Delta K	1

Task 3 Assign a calibration file

This task links a sensor calibration file (created in **Task 2**) to a hardware resource. The purpose for this is to select one of the sensor ranges for the input signal definition.

See “How to Assign a Sensor File” in Chapter 3, Station Manager of the *Model 793.00 System Software* manual for a detailed procedure.

Task 4 Turn on hydraulic pressure

WARNING

Do not place any part of your body in the path of a moving actuator.

A crush zone exists between the actuator and any equipment in the path of its movement. Immediate and unexpected actuator response is possible when you apply hydraulic pressure to your system.

Stay clear of the actuators when applying hydraulic pressure.

See "Turn on hydraulic pressure" on page 159 for a detailed procedure.

Task 5 Verify the conditioner polarity

This task checks the polarity of the conditioner. Different types of test systems are configured with different conditioner polarities. The polarity of the conditioner, the polarity of the valve driver, and the connection positions of system cabling all play a role in controlling the actuator and determining how signals are displayed.

This procedure assumes the servovalve polarity is set to **Normal** on the Station Setup **Drive** panel **Valve** tab.

1. Check the sensor connection.

   Be sure the force sensor is properly connected to the rear panel of the controller.

2. Apply a load to the force sensor.

   Push on the force sensor (with your hand) and note the signal value on the DVM or **Station Signals** panel.

   If the signal value is positive for actuator compression, the conditioner polarity is correct. If desired, you can change the conditioner polarity to make the signal value negative for actuator compression.

Note *The polarity setting should be the same when calibrating additional ranges for the same sensor.*

Task 6 Set the zero and offset

This task records the load standard readout as the zero reference.

Using a load standard

Adjust the **Manual Cmd** slider on the **Manual Command window** for 0 kN. Then zero the load standard readout.

Using dead weights

Remove all dead weights, and then click **Auto Offset** on the **Offset/ Zero** tab (**Inputs** panel).

Task 7 Gain/Delta K Calibration

If you are using **Gain/Delta-K** for your calibration type, complete the following procedure. If not, complete **Task 8 Gain/Linearization Calibration** on page 190 or **Task 9 Millivolt/Volt Calibration** on page 197

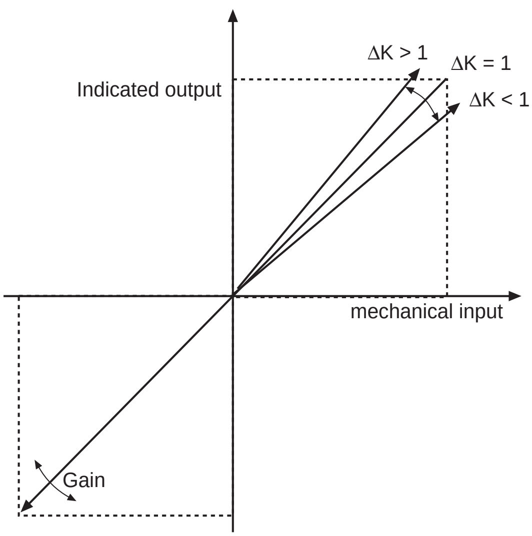
Calibrate tension

Force sensors can be calibrated so that a positive output represents actuator compression and a negative output represents actuator tension, and vice versa.

You calibrate the negative side of the output with gain and the positive side of the output with Delta K.

Delta K compensates for differences in symmetry between positive and negative outputs.

Calibrate compression at 80% full scale for each range.



Note *This procedure assumes a positive command extends the actuator and a negative command retracts the actuator. If not, use the opposite polarity for any values given.*

Gain controls

Pre-Amp gain is a selectable gain amplifier with predefined values. Since changes in **Pre-Amp** gain can cause spikes in the feedback signal, **Pre-Amp** gain can only be adjusted when hydraulics are off.

Post-Amp gain is a finer, operator-defined gain control that can be adjusted when hydraulics are on.

The **Total** gain value is calculated by multiplying the **Pre-Amp** and **Post-Amp** gain values. If the total desired gain amount is known (from a calibration sheet), you can enter the amount in the **Total** gain box

and the software will calculate the **Pre-Amp** and **Post-Amp** gain values automatically.

When you are calibrating an DC conditioner, use the **Post-Amp** gain control to increase gain. If more gain is needed, you must disable hydraulics and increase the **Pre-Amp** gain. You can then turn on hydraulics and continue to adjust the **Post-Amp** gain slider.

1. Exercise the force standard.

   Use the **Manual Cmd** slider on the **Manual Command** window to cycle the load standard readout between zero and full tension three times. This removes sensor hysteresis.

   Example: When calibrating a ±10 kN range, exercise the actuator between 0 and -10 volts. To calibrate the same force sensor for a different range such as ±5 kN, exercise the load standard between 0 and -5 volts.

2. Apply a tensile force command that is 80% of the range's full scale.

   Do this by adjusting the **Manual Cmd** slider on the **Manual Command** window, then verify that the **Station Signals** panel reads what you applied with the slider. During the initial calibration and tuning of your system, it may take repeated adjustment for the two values to match.

Note *If the actuator response is sluggish and/or the signal value does not match the command, you will need to adjust the tuning of this control mode. Increase the proportional gain (**P Gain** on the **Adjustments** tab of the **Tuning** panel) to correct sluggish actuator movement. Increase the reset integration value (**I Gain**) to help the feedback match the command.*

   At this point, unless the conditioner is already in calibration, the tensile force applied to the force transducer will not equal your commanded value. You will adjust gain in the next step so that the actual tensile force and your commanded tensile force match.

   Example: Suppose your actuator has a 100% tensile force rating of -10 kN. In this step you would apply -8 kN of command, and even though the station signals would read -8 kN of feedback, the force standard may only read -4 kN. This shows the conditioner/sensor pair are out of calibration.

3. Adjust gain until the actual tensile force equals your tensile force command.

   Adjust the **Post-amp Gain** control on the **Calibration** tab to increase the tensile force reading on the load standard until it equals your tensile force command.

4. Repeat steps 2 and 3 for all ranges.

   Example: Suppose you have an actuator with a full-scale capacity of ±10 kN and ranges of ±10 kN, ±5 kN, ±2 kN, and ±1 kN. In this case you would repeat this process and calibrate tension at 80% of each range (-8 kN, -4 kN, -1.6 kN, and -0.8 kN).

Note *Some systems do not provide or require multiple ranges, such as those using full-range conditioners (e.g., Model 493.25 DUC module). In this case, only one range is used (typically 100%).*

Note *This procedure assumes a positive command extends the actuator and a negative command retracts the actuator. If not, use the opposite polarity for any values given.*

Calibrate compression

1. Exercise the force sensor.

   Use the **Manual Cmd** slider on the **Manual Command** window to cycle the force standard readout between zero and full compression three times. This removes any hysteresis in the sensor.

   Example: When calibrating a ±10 kN range, exercise the load standard between 0 and 10 kN.

2. Apply a compressive force command that is 80% of the range's full scale.

   Do this by adjusting the **Manual Cmd** slider on the **Manual Command** window, then verify that the **Station Signals** panel reads what you applied with the slider. During the initial calibration and tuning of your system, it may take a while for the two values to match.

Note *If the actuator response is sluggish and/or the signal value does not match the command, you will need to adjust the tuning of this control mode. Increase the proportional gain (**P Gain** on the **Adjustments** tab of the **Tuning** panel) to correct sluggish actuator movement. Increase the reset integration value (**I Gain**) to help the feedback match the command.*

At this point, unless the conditioner is already in calibration, the compressive force applied to the force transducer will not equal your commanded value. You will adjust Delta K in the next step so that the actual compressive force and your commanded compressive force match.

Example: Suppose your actuator has a 100% compressive force rating of 10 kN. In this step you would apply 8 kN of command, and even though the station signals would read 8 kN of feedback, the force standard may only read 4 kN. This shows the conditioner/sensor pair are out of calibration.

3. Adjust Delta K until the actual compressive force equals your compressive force command.

   Adjust the **Delta K** control on the **Calibration** tab to increase the compressive force reading on the load standard until it equals your compressive force command.

4. Repeat steps 2 and 3 for all ranges.

   Example: Suppose you have an actuator with a full-scale capacity of ±10 kN and ranges of ±10 kN, ±5 kN, ±2 kN, and ±1 kN. In this case you would repeat this process and calibrate compression at 80% of each range (8 kN, 4 kN, 1.6 kN, and 0.8 kN).

Note *Some systems do not provide or require multiple ranges, such as those using full-range conditioners (e.g., Model 493.25 DUC module). In this case, only one range is used (typically 100%).*

Record data points

The accuracy tolerance of your data depends on the manufacturer of your sensor. Your sensor should include a calibration data sheet that shows the data point tolerance. Sensors from MTS include a sensor calibration data sheet that shows the data points as it was calibrated.

1. Record the data points for compression.

   A. Adjust the **Manual Cmd** slider on the **Manual Command** window to achieve a load standard readout of zero.

   B. Adjust the **Manual Cmd** slider between zero and full compression three times. This exercises the force sensor to remove hysteresis.

   C. Establish the zero reference.

Using a load standard

- Adjust **Manual Cmd** slider for 0 kN. Then zero the load standard readout.

Calibration

Using dead weights

- Remove all dead weights. On the **Inputs** panel, click on the **Offset/Zero** tab**,** and then adjust **Manual Offset** for a signal value of 0 kN on the DVM or **Station Signals** panel.

D. Adjust the **Manual Cmd** slider to achieve a load standard reading of 20% compression and record the meter reading. Repeat this step for 40%, 60%, 80%, and 100% compression.

2. Record the data points for the tension.

A.Adjust the **Manual Cmd** slider to achieve a load standard readout of zero.

B.Adjust the **Manual Cmd** slider between zero and full tension three times. This exercises the force sensor to remove hysteresis.

C.Establish the zero reference.

Using a load standard

- Adjust the **Manual Cmd** slider for 0 kN. Then zero the load standard readout.

Using dead weights

- Remove all dead weights. Then adjust the **Offset** control for a **Signal Value** of 0 kN on the **Input Signals** window.

D.Adjust the **Manual Cmd** slider to achieve a force standard reading of 20% tension and record the meter reading. Repeat this step for 40%, 60%, 80%, and 100% compression.

Task 8 Gain/Linearization Calibration

If you are using **Gain/Linearization** for your calibration type, complete the following procedure. If not, complete **Task 7 Gain/Delta K Calibration** on page 185 or **Task 9 Millivolt/Volt Calibration** on page 197**.**

Important *Using linearization data requires specific conditioner zeroing practices. Ensure that* ***Electrical Zero Lock*** *on the* ***Offset/ Zero*** *menu is set to* ***Locked****. Adjusting electrical zero after calibration may invalidate linearization data.*

Important *Changing conditioner polarity after calibration may invalidate linearization data. If you need to change conditioner polarity (for example, when moving a sensor to a different test system), the sensor may need to be recalibrated.*

Initial force sensor calibration

1. Select **Gain/Linearization** for **Cal Type** on the **Calibration** tab of the **Inputs** panel.
2. Exercise the force standard

   Use the **Manual Cmd** slider on the **Manual Command** window to cycle the load standard readout between zero and full tension three times. This removes sensor hysteresis.

   Example: When calibrating a ±10 kN range, exercise the actuator between 0 and -10 volts. To calibrate the same force sensor for a different range such as ±5 kN, exercise the load standard between 0 and -5 volts.
3. Apply a tensile force command that is 80% of the range's full scale.

   A. Adjust the **Manual Cmd** slider for a tensile force command that is 80% of the full scale range.

   B. Verify that your force transducer feedback signal is 80% of the full scale range.

   During the initial calibration and tuning of your system, it may require repeated adjustment for the tensile force command and feedback values to match.

Note *If the actuator response is sluggish and/or the feedback signal value does not match the command, you will need to adjust the tuning of this control mode. Increase the proportional gain (****P Gain*** *on the*

__Adjustments__ tab of the __Tuning__ panel) to correct sluggish actuator movement. Increase the reset integration value (__I Gain__) to help the feedback match the command.

At this point, unless the conditioner is already in calibration, the tensile force applied to the force transducer will not equal your commanded value. You will adjust gain in the next step so that the actual tensile force and your commanded tensile force match.

Example: Suppose your actuator has a 100% tensile force rating of -10 kN. In this step you would apply -8 kN of command, and even though the station signals would read -8 kN of feedback, the force standard may only read -4 kN. This shows the conditioner/sensor pair are out of calibration.

4. Adjust gain until the actual tensile force equals your tensile force command.

   Adjust the **Post-amp Gain** control on the **Calibration** tab to increase the tensile force reading on the load standard until it equals your tensile force command.

5. Apply a compressive force command that is 80% of the full scale range.

   A. Adjust the **Manual Command** slider for a compressive force command that is 80% of the full scale range.

   B. Use the **Station Signals** panel to verify that the compressive force signal is approximately equal to 80% of the full scale range.

6. Record force standard and conditioner feedback values at predetermined tensile force command points.

Note *After shutting down system hydraulics, you will enter these recorded readings on the Linearization Data window.*

   A. Adjust the **Manual Cmd** slider for a 0% command.

   B. Record the force standard’s readout value and corresponding conditioner feedback reading at 0% command.

   C. Adjust the **Manual Cmd** slider for a -2% tensile force command.

   D. Record the force standard’s readout value and its corresponding conditioner feedback reading in the -2% row of your record sheet.

E. Repeat steps E-G for other tensile force commands (typically at -4, -6, -8, -10, -20, -40, -70, and -100 percent of full scale).

7. Record conditioner feedback readings at predetermined compressive force command points.

   A. Adjust the **Manual Cmd** slider for a +2% compressive force command.

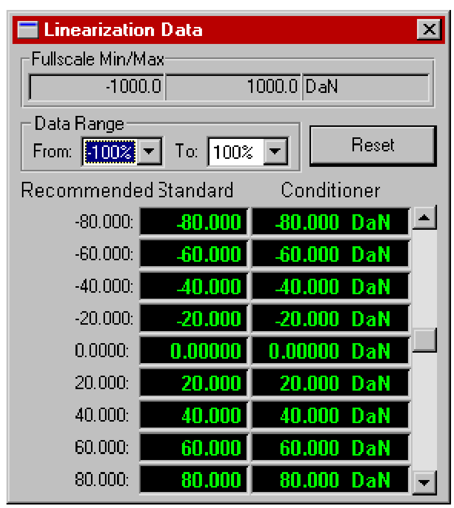
   B. Record the standard's readout signal and corresponding conditioner feedback reading in the +2% row of your record sheet.

   C. Repeat steps A and B for other compressive force commands (typically at +4, +6, +8, +10, +20, +40, +70, and +100 percent of full scale).

8. Turn off system hydraulics

9. On the Linearization Data window, enter the force standard values and corresponding conditioner feedback readings for all command points previously recorded on a separate sheet.

   Click **Linearization Data** on the **Calibration** tab to open the Linearization Data window.



Force sensor recalibration

If the force sensor has been previously calibrated, use the following procedure:

1. Locate the calibration data sheet for the appropriate conditioner.
2. Turn off system hydraulics.
3. Click **Linearization Data** on the **Calibration** tab to open the **Linearization Data** window.
4. Transfer **Standard** and **Conditioner** data from the conditioner's calibration data sheet to corresponding data entries on the **Linearization Data** window.
5. Turn on system hydraulics.
6. Verify linearization data.

   A. Adjust the **Manual Cmd** slider for each tensile and compressive force command point on the Linearization Data window.

   B. At each command point, verify both the dial indicator value (**Standard**) and its corresponding conditioner feedback value (**Conditioner**) by comparing them with the corresponding values on the Calibration Data sheet

   If the data is valid: **Stop** this procedure.

   If the data is not valid: **Proceed** to the next step.
7. Click **Reset** on the Linearization Data window to return to default values.
8. Exercise the force standard

   Use the **Manual Cmd** slider on the **Manual Command** window to cycle the load standard readout between zero and full tension three times. This removes sensor hysteresis.

   Example: When calibrating a ±10 kN range, exercise the actuator between 0 and -10 volts. To calibrate the same force sensor for a different range such as ±5 kN, exercise the load standard between 0 and -5 volts.
9. Apply a tensile force command that is 80% of the range's full scale.

   A. Adjust the **Manual Cmd** slider for a tensile force command that is 80% of the full scale range.

B. Verify that your force transducer feedback signal is 80% of the full scale range.

During the initial calibration and tuning of your system, it may require repeated adjustment for the tensile force command and feedback values to match.

Note *If the actuator response is sluggish and/or the signal value does not match the command, you will need to adjust the tuning of this control mode. Increase the proportional gain (**P Gain** on the **Adjustments** tab of the **Tuning** panel) to correct sluggish actuator movement. Increase the reset integration value (**I Gain**) to help the feedback match the command.*

At this point, unless the conditioner is already in calibration, the tensile force applied to the force transducer will not equal your commanded value. You will adjust gain in the next step so that the actual tensile force and your commanded tensile force match.

Example: Suppose your actuator has a 100% tensile force rating of -10 kN. In this step you would apply -8 kN of command, and even though the station signals would read -8 kN of feedback, the force standard may only read -4 kN. This shows the conditioner/ sensor pair are out of calibration.

10. Adjust gain until the actual tensile force equals your tensile force command.

    Adjust the **Post-amp Gain** control on the **Calibration** tab to increase the tensile force reading on the load standard until it equals your tensile force command.

11. Apply a compressive force command that is 80% of the full scale range.

    A. Adjust the **Manual Command** slider for a compressive force command that is 80% of the full scale range.

    B. Use the **Station Signals** panel to verify that the compressive force signal is approximately equal to 80% of the full scale range.

12. Record conditioner feedback readings at predetermined tensile force command point.

Note *After shutting down system hydraulics, you will enter these recorded readings on the Linearization Data window.*

   A. Adjust the **Manual Cmd** slider for a 0% command.

   B. Record the force standard readout signal and corresponding conditioner feedback reading at the 0% command line of your record sheet.

   C. Adjust the **Manual Cmd** slider for a -2% tensile force command.

   D. Record the force standard readout signal and corresponding conditioner feedback reading at the -2% command line of your record sheet.

   E. Repeat steps C and D for other tensile force commands (typically at -4, -6, -8, -10, -20, -40, -70, and -100 percent of full scale).

13. Record conditioner feedback readings at predetermined compressive force command points.

   A. Adjust the **Manual Cmd** slider for a +2% compressive force command.

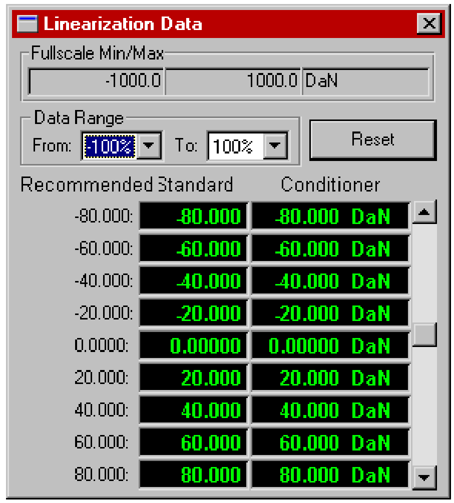
   B. Record the force standard readout signal and corresponding conditioner feedback reading at the +2% command line of your record sheet.

   C. Repeat steps A and B for other compressive force commands (typically at +4, +6, +8, +10, +20, +40, +70, and +100 percent of full scale).

14. Turn off system hydraulics.

15. On the Linearization Data window, enter the force standard values and corresponding conditioner feedback readings for all command points previously recorded on a separate sheet.

    Click **Linearization Data** to open the **Linearization Data** window.



16. Turn on system hydraulics.

17. Verify linearization data.

    A. Adjust the **Manual Cmd** slider for each retraction and extension command point on the Linearization Data window.

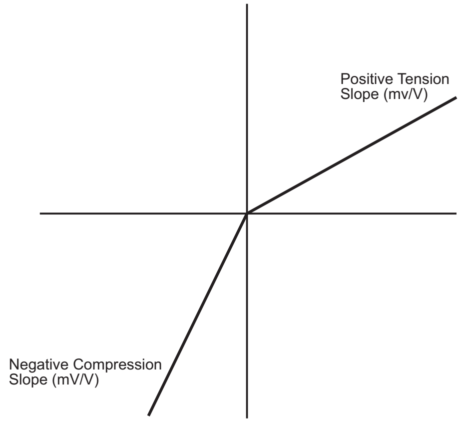
    B. At each command point, verify both the force standard value (**Standard**) and its corresponding conditioner feedback value (**Conditioner**).

    C. Check validity before entering each pair of values on a new Calibration Data Sheet.

Task 9 Millivolt/Volt Calibration

If you are using **mV/V Calibration** for your calibration type, complete the following procedure. If not, complete **Task 7 Gain/Delta K Calibration** on page 185 or **Task 8 Gain/Linearization Calibration** on page 190.

Millivolt/volt calibration is used for transducers that have two different slopes (positive and negative).



In this calibration process, system software calculates conditioner Delta K Gain and Gain values from previously measured mV/V values under both tension and compression.

The slope and gain values are derived from, and are relative to, the output of the load cell transducer as follows:

$$\text{Delta K Gain} = \frac{\text{Compression mV/V}}{\text{Tension mV/V}}$$

Where:

Compression is specified using the **Neg Compression** or **Pos Compressive** entry box on the Calibration tab.

Tension is specified using the **Neg Tension** or **Pos Tension** entry box on the Calibration tab.

Calibration

$$\text{Gain} = \frac{\text{Conditioner Output Voltage}}{\text{Excitation Voltage} \times \text{Compression mV/V}}$$

Where:

Conditioner Output Voltage is typically 10 Vdc.

Excitation Voltage is specified using the **Excitation** entry box on the **Calibration** tab.

Compression is specified using the **Negative Compression** or **Positive Compressive** entry box on the **Calibration** tab.

mV/V positive tension calibration

Use the following procedure if your force transducer is set up so that a positive output represents actuator retraction (tension).

1. Select **mV/V Pos Tension** for **Cal Type** on the **Calibration** tab of the **Inputs** panel.

Note *For convenience during mV/V positive tension calibration, **Gain** and **Delta K** are presented as read-only displays on the **Inputs** panel.*

2. From the Calibration Data sheet for your force transducer, enter the following values on the **Calibration** tab:

    A. Enter the full scale force values in the **Fullscale Min/Max** entry boxes.

    B. Adjust **Pos Tension** for the required tension sensitivity value (+mV/V).

    C. Adjust **Neg Compression** for the required compression sensitivity value (-mV/V).

    D. Adjust **Excitation** for the required calibration excitation value (Vdc).

mV/V positive compression calibration

Use the following procedure if your force transducer is set up so that a positive output represents actuator extension (compression).

1. Select **mV/V Pos Compression** for **Cal Type** on the **Calibration** tab of the **Inputs** panel.

Note *For convenience during mv/v positive compression calibration, **Gain** and **Delta K** are presented as read-only displays on the **Inputs** panel.*

2. From the Calibration Data sheet for your force transducer enter the following values on the **Calibration** tab:

   A. Enter the full scale force values in the **Fullscale Min/Max** entry boxes.

   B. Adjust **Neg Tension** for the required tension sensitivity value (+mV/V).

   C. Adjust **Pos Compression** for the required compression sensitivity value (-mV/V).

   D. Adjust **Excitation** for the required calibration excitation value (Vdc).

Task 10 Establish the shunt calibration reference

Each resistive bridge type transducer (DC sensor) uses a shunt resistor to check the calibration accuracy of the sensor/conditioner combination. Each DC conditioner supports a shunt resistor.

1. Turn off hydraulic power.
2. Remove the load standard.
3. Turn on hydraulic power.
4. Zero the force sensor output.

   Adjust the **Manual Cmd** slider on the **Manual Command** window for a 0 kN output. The sensor output must be 0.000 kN for a proper shunt calibration. If not, return to “Set the zero and offset” on page 184.
5. Change the control mode.

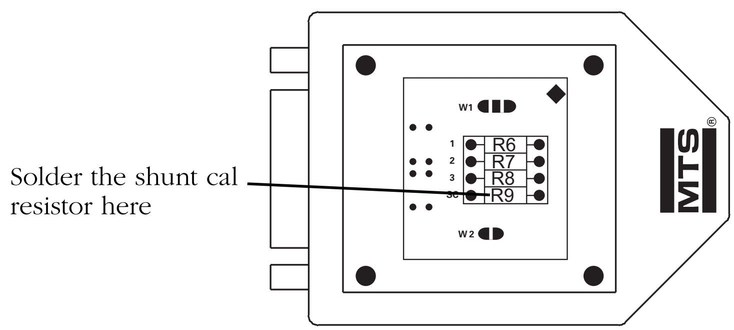
   Change **Control mode** on the **Manual Command** window to a **Displacement** control mode. Shunt calibration cannot be performed on a sensor when it is in control of the servo loop.
6. Determine the shunt calibration resistor from the following table:

BRIDGE RESISTANCE	SENSITIVITY	RANGE (% FULL SCALE)	RESISTOR VALUE
350 Ω	2 mV/V	100% 50% 20% 10%	49.9 k 100 k 249 k 499 k
350 Ω	1 mV/V	100% 50% 20% 10%	100 k 200 k 499 k 1000 k

BRIDGE RESISTANCE	SENSITIVITY	RANGE (% FULL SCALE)	RESISTOR VALUE
700 Ω	2 mV/V	100% 50% 20% 10%	100 k 200 k 499 k 1000 k
700 Ω	1 mV/V	100% 50% 20% 10%	200 k 402 k 1000 k 2000 k

7. If you have sensor cables with optional transducer ID modules, complete the following procedure. If not, proceed to Step 8.

   Install the shunt calibration resistor into the **R9** location of the sensor ID module. The sensor identification cartridge is molded into the sensor cable.



8. If you do not have transducer ID modules on your sensor cables, install the shunt calibration resistor as follows:

   A. Select the appropriate shunt calibration resistor.

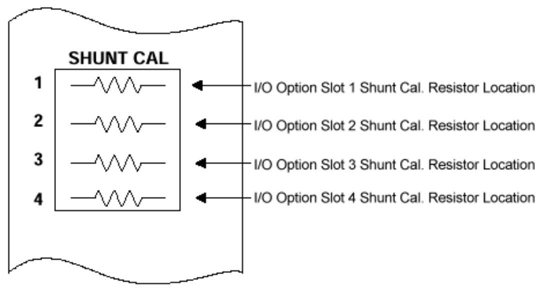
   B. Bend the resistor leads 90° for a 0.3 inch separation.

   C. Cut the resistor leads 0.12 inch from the bend.

   D. Insert the resistor into the connector solder cups and solder.

   E. Complete and attach a shunt calibration label as specified on the 493.40/41 Carrier I/O Shunt Calibration Kit (MTS PN 100-028-185).

F. Install the shunt cal resistor/connector assembly into the appropriate slot of the **SHUNT CAL** connector on the front panel of the appropriate I/O Carrier Module.



9. Verify that force is still zero.

   While it is unlikely, it is possible for the force signal to change when the control mode changes. If it does, click **Auto Offset** on the **Offset/Zero** tab (**Inputs** panel) to zero the force output.

10. Perform shunt calibration.

    The shunt calibration controls are located on the **Shunt** tab in the **Inputs** panel.

    A. In **Station Setup** select the appropriate force channel on the navigation panel**.,** click the **Channel Input Signals** icon, and then click the **Shunt** tab.

    B. Select the shunt type. Use (+) polarity if you are not sure what to select.

    C. In the **Current Shunt Value** box, click the **On** button. Note the **Current Shunt Value**, it should be 60%–90% (80% is ideal) of the calibrated range of the sensor.

    D. Click **Update** to copy the **Current Shunt Value** into the **Shunt Reference Value** box, and then click **Off**.

Task 11 Save the calibration

It is important that you save your sensor calibration values.

On the **Station Setup** window **Inputs** panel, click the **Calibration** tab, and then **Save**. This saves current calibration values on the **Calibration**, **Sensor**, and **Shunt** tabs to the sensor calibration file.

Task 12 Calibrate additional ranges

This task describes how to calibrate additional ranges. Each sensor calibration file can have calibration data for four ranges. If you have a need for additional ranges, simply create another sensor calibration range.

- Use the calibration values from the previous range as a starting point.
- If you adjust the zero reference, it may affect the other ranges.

Note *Some systems do not provide or require multiple ranges, such as those using full-range conditioners (e.g., Model 493.25 DUC module). In this case, only one range is used (typically 100%).*

Adding a range

If the sensor calibration file must have additional ranges defined, perform the following:

1. On the **Tools** menu, select **Sensor File Editor**.
2. Open the sensor file for the sensor you have just calibrated.
3. Click **Add** under **Range Definition**.
4. Select the units for the range, and then enter the absolute value of the range.
5. Save the new range to the calibration file.
6. Calibrate the added range

Note *Ranges can also be added on the* ***Sensor*** *tab and calibrated on the* ***Calibration*** *tab.*

Calibrating Encoders

Encoders are connected to the controller through a 493.40 Carrier I/O board. The encoder requires the Model 493.47 Encoder Interface daughter board to be installed in a Model 493.40 Carrier I/O board. The Carrier I/O connector you use is based on the installed location of the Model 493.47 Encoder Interface daughter board on the board of the Carrier I/O module.

Determine installed location

To determine the installed location of the Model 493.47 Encoder Interface daughter board, use the **Hardware** tab on the **Station Signals** window. Access **Station Signals** on the **Station Setup** window navigation pane.

Defining an input

Defining an encoder sensor input signal is no different from any other input signal. However, specific resources must be available to define either input signal. Use the Station Builder program to allocate an encoder to the station configuration file and assign units to the signal.

Feedback resources labeled “Encoder Input #” or “Heidenhain 417/425 Input #” indicate that an optional encoder daughter board is installed in the Model 493.40 Carrier I/O board.

Zeroing

The encoder signal is defined in the Station Setup **Inputs** panel. Signal definition is handled the same way as any other input signal.

Note *Keep in mind that you cannot zero an encoder if it is selected for the active control mode.*

Note *The most common use for these controls is to establish a zero position after a specimen has been installed.*

Abbreviated Procedure

Online readers *All procedure entries are hypertext links.*
Click on any entry to jump to the corresponding page.

The following abbreviated procedure outlines an encoder calibration process. More detailed calibration information is available on the pages listed.

Task 1 Get things ready

Perform the following before you start encoder calibration.

1. Locate relevant documentation.

   When calibrating an encoder, you will need information about the encoder such as the serial number, model number, and a specification called measuring step (resolution).

2. Open a station configuration file.

   You need a station configuration file that includes a control channel and a control mode that uses the encoder you intend to calibrate.

   On the **File** menu, select **Open Station** to open the appropriate configuration file.

3. Enter the Calibration password.

   You must access the Calibration user access level before you can perform any of the calibration procedures.

   On the **Station Manager** toolbar, select the **Calibration** user level on the Access Level list. Type the required password. By default, the password is *Calibration*; however, it can be changed during the software installation procedure.

4. Set up a signal monitor.

Note *You cannot monitor the output of a new sensor until a sensor calibration file has been created and the sensor assigned to an input signal.*

   You will be monitoring encoder output when making adjustments throughout this procedure. You can monitor the encoder output in the same units that you are using for the calibration.

   You can use an external DVM to monitor encoder output from a BNC connector on the Analog Out panel located on your controller chassis.

   If you do not have an Analog Out panel, use the **Meters** window or **Station Signals** panel to monitor sensor output. On the Station Manager **Display** menu, select **Station Setup**. In the navigation pane, select **Station Signals** to display the **Station Signals** panel to monitor current values for user-defined signals.

Task 2 Create a calibration file

Note *If you already have a sensor calibration file, skip this task.*

This task creates a sensor calibration file and sets up any ranges you may want. An encoder does not require ranges, its resolution is always the same.

See “How to Create a Sensor File” in Chapter 3, Station Manager of the *Model 793.00 System Software* manual for a detailed procedure.

Setting encoder resolution

In the **Resolution** box, enter the encoder resolution supplied in the encoder documentation.

Note *If want to use units different than those supplied in the sensor documentation, enter the full scale and resolution in the supplied units first, and then switch to the desired full-scale units. The units conversion will be calculated automatically.*

Note *When you change the encoder resolution on the* ***Calibration*** *tab, it immediately changes the resolution of signal values displayed on the* ***Station Signals****,* ***Meters****, and* ***Scope*** *windows.*

Task 3 Assign a calibration file

This task links a sensor calibration file (created in **Task 2**) to a hardware resource. The purpose for this is to select one of the sensor ranges for the input signal definition.

See “How to Assign a Sensor File” in Chapter 3, Station Manager of the *Model 793.00 System Software* manual for a detailed procedure.

Task 4 Turn on hydraulic pressure

This task sets up the **Control Panel** so you can turn on the hydraulic pressure.

WARNING

Do not place any part of your body in the path of a moving actuator.

A crush zone exists between the actuator and any equipment in the path of its movement. Immediate and unexpected actuator response is possible when you apply hydraulic pressure to your system.

Stay clear of the actuators when applying hydraulic pressure.

See "Turn on hydraulic pressure" on page 159 for a detailed procedure.

Task 5 Set the zero position

The zero position can be set anywhere within the full-scale range of the encoder.

A. Adjust the **Manual Cmd** slider on the **Manual Command** window to move the actuator to the position you want to assign as zero.

B. Use **Control Mode** on the Change control modes on the **Control Panel**. Select any control mode that does not use the encoder.

Note *If the actuator should move after making the change in control modes, you will need to reposition the actuator, then change to a more stable control mode.*

C. With the actuator in the desired zero position, click the **Auto Zero** button on the **Offset/Zero** tab (**Inputs** panel).

Task 6 Save the calibration

It is important that you save your sensor calibration values.

On the **Station Setup** window **Inputs** panel, click the **Calibration** tab, and then **Save**. This saves current calibration values on the **Calibration**, **Sensor**, and **Shunt** tabs to the sensor calibration file.

Calibrating Temposonics Sensors

Temposonics sensors require a Model 493.47 Encoder Interface daughter board to be installed in a Model 493.40 Carrier I/O board. The Carrier I/O connector used depends on the installed location of the daughter board on the board of the Carrier I/O module.

Determine installed location

To determine the installed location of the Model 493.47 Encoder Interface, use the **Hardware** tab on the **Station Signals** window. Access **Station Signals** on the **Station Setup** window navigation panel.

Defining an input

Defining a Temposonics sensor input signal is no different from any other input signal. Use the Station Builder application to allocate a Temposonics sensor to the station configuration file. The Station Builder application also assigns units to the signal.

Feedback Resources labeled “Temposonics Input #” or “Temposonics III Input #” indicate that the optional Temposonics daughter board (Model 493.47 Encoder Interface) is installed in the Model 493.40 Carrier I/O board.

Abbreviated Procedure

Online readers *All procedure entries are hypertext links.*
Click on any entry to jump to the corresponding page.

The following abbreviated procedure outlines a Temposonics sensor calibration process. More detailed calibration information is available on the pages listed.

Task 1 Get things ready

1. Review "Before You Begin" on page 147
2. Locate relevant documentation.

   When calibrating a Temposonics sensor, you will need information about the sensor such as the serial number, model number, a specification called measuring step (resolution), etc.
3. Open a station configuration file.

   You need a station configuration file that includes a control channel and a control mode that uses the Temposonics sensor you intend to calibrate.

   On the **File** menu, click **Open Station** to open the appropriate configuration file.
4. Enter the Calibration password.

   You must access the Calibration user access level before you can perform any of the calibration procedures.

   On the **Station Manager** toolbar, select the **Calibration** user level on the Access Level list.
5. Set up a signal monitor.

Note *You cannot monitor the output of a new sensor until a sensor calibration file has been created and the sensor assigned to an input signal.*

   You will be monitoring temposonics sensor output when making adjustments throughout this procedure. You can monitor the temposonics sensor output in the same units that you are using for the calibration.

   You can use an external DVM to monitor temposonics sensor output from a BNC connector on the Analog Out panel located on your controller chassis.

   If you do not have an Analog Out panel, use the **Meters** window or **Station Signals** panel to monitor sensor output. On the Station Manager **Display** menu, select **Station Setup**. In the navigation pane, select **Station Signals** to display the **Station Signals** panel to monitor current values for user-defined signals.

Task 2 Create a calibration file

This task creates a sensor calibration file and sets up any ranges you may want. A Temposonics sensor does not require ranges, its resolution is always the same.

See “How to Create a Sensor File” in Chapter 3, Station Manager of the *Model 793.00 System Software* manual for a detailed procedure.

Setting Temposonics resolution

In the **Resolution** box, enter the Temposonics resolution supplied in the Temposonics documentation.

Note *If want to use units different than those supplied in the sensor documentation, enter the full scale and resolution in the supplied units first, and then switch to the desired full-scale units. The units conversion will be calculated automatically.*

Task 3 Assign the calibration file

This task links a sensor calibration file (created in **Task 2**) to a hardware resource; effectively selecting one of the sensor ranges for the input signal definition.

See “How to Assign a Sensor File” in Chapter 3, Station Manager of the *Model 793.00 System Software* manual for a detailed procedure.

Task 4 Turn on hydraulic pressure

This task sets up the **Control Panel** so you can turn on the hydraulic pressure.

WARNING

Do not place any part of your body in the path of a moving actuator.

A crush zone exists between the actuator and any equipment in the path of its movement. Immediate and unexpected actuator response is possible when you apply hydraulic pressure to your system.

Stay clear of the actuators when applying hydraulic pressure.

See "Turn on hydraulic pressure" on page 159 for a detailed procedure.

Task 5 Set the zero position

The zero position can be set anywhere within the full-scale range of the Temposonics sensor.

1. Adjust the **Manual Cmd** slider on the **Manual Command** window to move the actuator to the position you want to assign as zero.
2. Use **Control Mode** on the **Control Panel** to select any control mode that does not use the Temposonics sensor.

Note *If the actuator should move after making the change in control modes, you will need to reposition the actuator, then change to a more stable control mode.*

3. With the actuator in the desired zero position, click the **Auto Zero** button on the **Offset/Zero** tab (**Inputs** panel).

Note *When you change the encoder resolution on the **Calibration** tab, it immediately changes the resolution of signal values displayed on the **Station Signals**, **Meters**, and **Scope** windows.*

Task 6 Save the calibration

It is important that you save your sensor calibration values.

On the **Station Setup** window **Inputs** panel, click the **Calibration** tab, and then **Save**. This saves current calibration values on the **Calibration**, **Sensor**, and **Shunt** tabs to the sensor calibration file.

Calibrating an Extensometer

Extensometers are usually calibrated such that the maximum strain represents ±100% of the full-scale capacity of the extensometer.

To calibrate you extensometer you will need:

- An extensometer calibrator
- A digital voltmeter (DVM)

How To Calibrate an Extensometer

Online readers *All procedure entries are hypertext links. Click on any entry to jump to the corresponding page.*

Task 1 Get things ready

1. Review “Before You Begin” on page 147.
2. Locate all relevant documentation including information about the extensometer such as the serial number, model number, etc.
3. Open a station configuration file.

   You need a station configuration file that includes a control channel with a control mode that uses the extensometer you intend to calibrate.

   On the **File** menu, click **Open Station** to open the appropriate configuration file.
4. Enter the Calibration password.

   You must access the Calibration user access level before you can perform any of the calibration procedures.

   On the **Station Manager** toolbar, select the **Calibration** user level on the Access Level list.
5. Set up a signal monitor.

Note *You cannot monitor the output of a new sensor until a sensor calibration file has been created and the sensor assigned to an input signal.*

   You will be monitoring strain feedback when making adjustments throughout this procedure. You can monitor strain feedback in the same units that you are using for the calibration.

   You can use an external DVM to monitor strain feedback from a BNC connector on the Analog Out panel located on your controller chassis.

   If you do not have an Analog Out panel, use the **Meters** window or **Station Signals** panel to monitor strain feedback. On the Station Manager **Display** menu, select **Station Setup**. In the navigation pane, select **Station Signals** to display the **Station Signals** panel to monitor current values for user-defined signals.
6. Mount the extensometer to the calibrator.

   Review the extensometer product manual for mounting information and calibrator requirements.

Task 2 Create a sensor calibration file

This task creates a sensor calibration file and sets up any ranges you may want. If you already have a sensor calibration file, skip this task.

The following steps provide an overview of sensor file creation. For a more detailed description of this procedure, refer to "How to Create a Sensor File" in Chapter 3, Station Manager of the *Model 793.00 System Software* manual

1. On Station Manager **Tools** menu, select **Sensor File Editor**.
2. On the **Sensor File Editor** toolbar, click the **Open** button, and then **New**.
3. From the **Conditioner Type** list, select the type (Model #) of conditioner that is connected to the extensometer you are calibrating.

Note *Until you select conditioner type, all conditioner entries are disabled.*

4. Enter a sensor name.
5. Specify the signal **Dimension**.
6. Enter any additional information.
7. Under **Range Definition**, define a range.
8. Define the full scale of the range.
9. Set the sensor full scale and resolution.

   Set the units and enter the full-scale minimum and maximum for the range. The system software supports non-symmetrical full scales.

   In the **Resolution** box, enter the resolution value supplied in the extensometer documentation.

Note *If you want to use units different than those supplied in the sensor documentation, enter the full scale and resolution in the supplied units first, and then switch to the desired full-scale units. The units conversion will be calculated automatically.*

10. Enter initial calibration values.
11. Save your sensor file and close the **Sensor File Editor**.

Task 3 Assign a sensor calibration file

This task links a sensor calibration file (created in **Task 2**) to a hardware resource. The purpose for this is to select one of the sensor ranges for the input signal definition.

For a detailed description of this procedure, refer to "How to Assign a Sensor File" in Chapter 3, Station Manager of the *Model 793.00 System Software* manual.

Task 4 Turn on hydraulic pressure

This task activates the hydraulic pressure and ensures you have control of your actuator.

WARNING

Do not place any part of your body in the path of a moving actuator.

A crush zone exists between the actuator and any equipment in the path of its movement. Immediate and unexpected actuator response is possible when you apply hydraulic pressure to your system. Stay clear of the actuators when applying hydraulic pressure.

1. On the Station Manager window, ensure that the channel associated with the extensometer signal you are calibrating has strain selected for its active control mode.
2. If the **Interlock** indicator is lit, click **Reset**. If the indicator lights again, you must determine the cause and correct it before proceeding.
3. In the power selection box, click the **Power Low** button, and then **Power High** for the HPU. If an HPU is not listed, start the HPU at the pump.

Note *The HPU can be configured for "first on." If this is the case, start the appropriate HSM.*

4. If an HSM is present, click the **Power Low** button, and then **Power High** for the appropriate HSM.
5. Apply a positive strain command, and observe the strain feedback value on your meter.

   If you have control of the actuator, proceed to Task 5 on page 220.

   If you do not have control of the actuator (for example, the actuator is hunting or moving in the wrong direction), disable hydraulics, change the conditioner polarity, and then perform Task 4 again.

For more detailed information on applying hydraulic pressure and clearing interlocks, refer to *Chapter 3, Station Manager* in the *Model 793.00 System Software* manual.

Task 5 Adjust offset

This task verifies the sensor's zero position and offsets any imbalance due to specimen size, forces from test components, cable length, and so forth. The zero position can be set anywhere within the full-scale range of the strain sensor.

Note *The arms of the extensometer must be in the zero reference position. Depending on the extensometer, this can be accomplished using the zero pin, stop block, or a special fixture.*

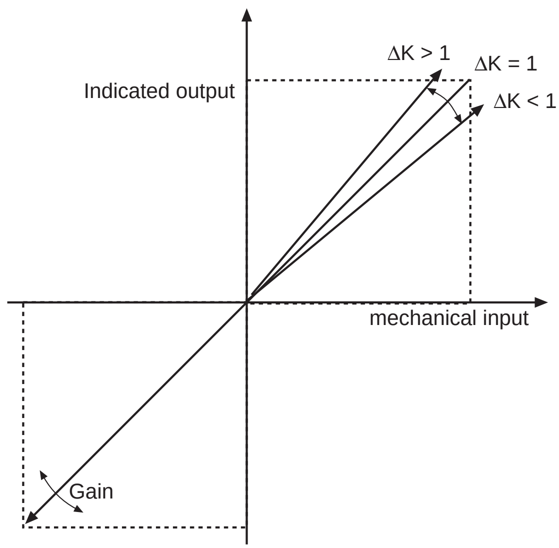
1. Adjust the **Manual Cmd** slider for 0 cm/cm.
2. Click Auto Offset icon on the **Station Controls** panel to display the **Signal Auto Offset** window.
3. If the current strain output is not zero, click the Auto Offset icon next to the signal value to offset it. automatically.

Task 6 Gain/Delta K Calibration

If you are using **Gain/Delta K** for your calibration type, complete the following procedure. If not, complete **Task 7 Gain/Linearization Calibration** on page 223.

Calibrate the negative output (tension)

This task calibrates the extensometer negative output using the calibration **Gain** controls. Since the **Gain** setting will affect your **Delta K** setting, you should always calibrate the negative side first.



To calibrate the negative extensometer output:

1. Use the **Manual Cmd** slider to adjust the calibrator between zero and 100% of the extensometer's full-scale range three times. This exercises the extensometer to remove any hysteresis
2. Apply a negative command equal to 80% of the negative full scale value (in this example, –8 cm/cm).
3. Note the strain signal value on your meter.
4. If the signal value does not match the commanded level, increase the **Post-Amp** Gain control on the **Calibration** tab to achieve an 80% value (–8 cm/cm). Record your final strain signal value from the meter for the 80% output.

Note *If you cannot apply enough **Post-amp** gain to achieve an 80% value, you will need to disable hydraulics, change the **Excitation** voltage, enable hydraulics, and then repeat this task.*

5. Repeat steps 1–4 for a 20%, 40%, 60%, and 100% negative output.

Calibrate the positive output (compression)

To calibrate the positive extensometer output:

1. Use the **Manual Cmd** slider to adjust the calibrator between zero and 100% of the extensometer's full-scale range three times. This exercises the extensometer to remove any hysteresis
2. Apply a positive command equal to 80% of the positive full scale value (in this example, +8 cm/cm).
3. Monitor the strain signal value on your meter.
4. If the extensometer signal value is above +8 cm/cm, adjust the **Delta K** control on the **Calibration** tab to achieve an 80% value (+8 cm/cm). Record your final strain signal value from the meter for the 80% output.

   If the extensometer signal is below +8 cm/cm, **Delta K** adjustment cannot be made. Return the **Delta K** adjustment to its original setting. Use the **Post-amp** gain control to increase the calculated output to a value halfway between its present value and +8 cm/cm (this splits the difference between compression and tension).
5. Repeat steps 1- 4 for a 20%, 40%, 60%, and 100% positive output.

Compare recorded data points to calibration sheet

Your sensor should include a calibration data sheet that shows the data point tolerance.

1. Compare your recorded output values to the calibration data sheet that accompanied your sensor.
2. Make sure your current values fall with the permissible variation.

If they do not, you must go back to recalibrate the extensometer negative and positive outputs.

Task 7 Gain/Linearization Calibration

If you are using **Gain/Linearization** for your calibration type, complete the following procedure. If not, complete **Task 6 Gain/Delta K Calibration** on page 221.

Important *Using linearization data requires specific conditioner zeroing practices. Ensure that **Electrical Zero Lock** on the **Offset/ Zero** menu is set to **Locked**. Adjusting electrical zero after calibration may invalidate linearization data.*

Initial extensometer calibration

1. Adjust the **Manual Cmd** slider on the **Manual Command** to adjust the calibrator between zero and 100% of the extensometer's full-scale range three times. This exercises the extensometer to remove any hysteresis.

2. Apply a negative strain command that is 80% of the negative full scale range.

    A. Adjust the **Manual Cmd** slider for a negative strain command that is 80% of the full scale range.

    B. Verify that your extensometer feedback signal is 80% of the full scale range.

    During the initial calibration and tuning of your system, it may require repeated adjustment for the negative strain command and feedback values to match.

    At this point, unless the conditioner is already in calibration, the negative strain applied to the extensometer will not equal your commanded value. You will adjust gain in the next step so that the actual strain and your commanded strain match.

3. Adjust gain until the actual strain equals your strain command.

    Adjust the **Post-amp Gain** control to increase the negative strain reading on the calibrator until it equals your negative strain command.

4. Apply a positive strain command that is 80% of the positive full scale range.

    A. Adjust the **Manual Cmd** slider for a positive strain command that is 80% of the full scale range.

B. Verify that your extensometer feedback signal is 80% of the full scale range.

5. Record conditioner feedback readings at predetermined negative strain command points.

Note *After shutting down system hydraulics, you will enter these recorded readings on the Linearization Data window.*

A. Adjust the **Manual Cmd** slider on the **Manual Command** window for a 0% command.

B. Record the calibrator's readout value and the corresponding conditioner feedback reading in the 0% row of your record sheet.

C. Adjust the **Manual Cmd** slider for a -2% strain command.

D. Record the calibrator's readout value and corresponding conditioner feedback reading in the -2**%** row of your record sheet.

E. Repeat steps C and D for other negative strain commands (typically at -4, -6, -8, -10, -20, -40, -70, and -100 percent of full scale).

6. Record conditioner feedback readings at predetermined positive strain command points.

A. Adjust the **Manual Cmd** slider for a +2% positive strain command.

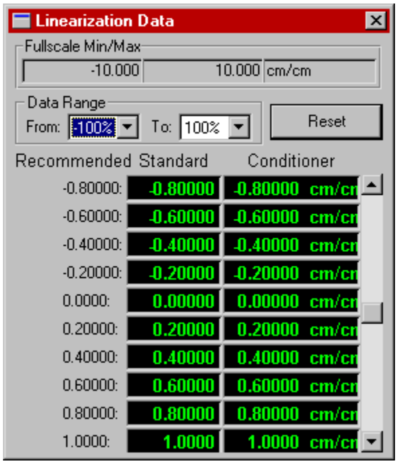
B. Record the calibrator's readout value and corresponding conditioner feedback reading in the +2% row of your record sheet.

C. Repeat steps A and B for other positive strain commands (typically at +4, +6, +8, +10, +20, +40, +70, and +100 percent of full scale).

7. Turn off system hydraulics.

8. Open the Linearization Data window and enter the calibrator readout values and corresponding conditioner feedback readings for all command points previously recorded on a separate sheet.

Click **Linearization Data** on the **Calibration** tab.



9. Turn on system hydraulics.

Extensometer recalibration

If the extensometer has been previously calibrated, use the following procedure:

1. Locate the calibration data sheet for the appropriate conditioner.
2. Turn off system hydraulics.
3. Click **Linearization Data** on the **Calibration** tab to open the Linearization Data window.
4. Transfer **Standard** and **Conditioner** data from the conditioner's calibration data sheet to corresponding data entries on the Linearization Data window.
5. Turn on system hydraulics.
6. Verify linearization data.

   A. Adjust the **Manual Cmd** slider for each strain command point on the Linearization Data window.

   B. At each command point, verify both the calibrator readout value (**Standard**) and its corresponding conditioner feedback value (**Conditioner**) by comparing them with the corresponding values on the Calibration Data sheet

   If the data is <u>valid</u>: **Stop** this procedure.

   If the data is <u>not valid</u>: **Proceed** to the next step.

7. Click **Reset** on the Linearization Data window to return to default values.

8. Use the **Manual Cmd** slider to adjust the calibrator between zero and 100% of the extensometer's full-scale range three times. This exercises the extensometer to remove any hysteresis.

9. Apply a negative strain command that is 80% of the negative full scale range.

   A. Adjust the **Manual Cmd** slider for a negative strain command that is 80% of the full scale range.

   B. Verify that your extensometer feedback signal is 80% of the full scale range.

   During the initial calibration and tuning of your system, it may require repeated adjustment for the negative strain command and feedback values to match.

   At this point, unless the conditioner is already in calibration, the negative strain applied to the extensometer will not equal your commanded value. You will adjust gain in the next step so that the actual strain and your commanded strain match.

10. Adjust gain until the actual strain equals your strain command.

    Adjust the **Post-amp Gain** control on the **Calibration** tab to increase the negative strain reading on the calibrator until it equals your negative strain command.

11. Apply a positive strain command that is 80% of the positive full scale range.

    A. Adjust the **Manual Cmd** slider for a positive strain command that is 80% of the full scale range.

    B. Verify that your extensometer feedback signal is 80% of the full scale range.

12. Record conditioner feedback readings at predetermined negative strain command points.

Note *After shutting down system hydraulics, you will enter these recorded readings on the Linearization Data window.*

    A. Adjust the **Manual Cmd** slider for a 0% command.

    B. Record the calibrator's readout value and the corresponding conditioner feedback in the 0% row of your record sheet.

C. Adjust the **Manual Cmd** slider for a -2% strain command.

D. Record the calibrator's readout value and the conditioner feedback reading in the -2% row of your record sheet.

E. Repeat steps C and D for other negative strain commands (typically at -4, -6, -8, -10, -20, -40, -70, and -100 percent of full scale).

13. Record conditioner feedback readings at predetermined positive strain command points.

    A. Adjust the **Manual Cmd** slider for a +2% positive strain command.

    B. Record the standard's readout value and the conditioner feedback reading at the +2% row of your record sheet.

    C. Repeat steps A and B for other positive strain commands (typically at +4, +6, +8, +10, +20, +40, +70, and +100 percent of full scale).

14. Turn off system hydraulics.

15. On the Linearization Data window, enter the calibrator values ((**Standard**) and its corresponding conditioner feedback readings (**Conditioner**) for all command points previously recorded on a separate sheet.

16. Verify linearization data.

    A. Adjust the **Manual Cmd** slider for each strain command point on the Linearization Data window.

    B. At each command point, verify both the calibrator readout value (**Standard**) and its corresponding conditioner feedback value (**Conditioner**).

    C. Check validity before entering each pair of values on a new Calibration Data sheet.

Task 8 Establish the shunt calibration reference

Each DC conditioner supports a shunt resistor. To establish the shunt reference value, perform the following tasks.

1. Disable hydraulic pressure and remove the calibrator.
2. Activate hydraulic pressure and zero the strain sensor output.

   Adjust the **Manual Cmd** slider for a 0 cm/cm output. The sensor output must be 0.000 cm/cm for a proper shunt calibration. If not, review Task 5, "Adjust offset," on page 220.
3. On the **Manual Command** window, change your control mode to displacement.
4. Determine the shunt calibration resistor from the following table:

Bridge Resistance	Sensitivity	Range (% Full Scale)	Resistor Value
350 Ω	2 mV/V	100% 50% 20% 10%	49.9 k 100 k 249 k 499 k
350 Ω	1 mV/V	100% 50% 20% 10%	100 k 200 k 499 k 1000 k
700 Ω	2 mV/V	100% 50% 20% 10%	100 k 200 k 499 k 1000 k
700 Ω	1 mV/V	100% 50% 20% 10%	200 k 402 k 1000 k 2000 k

5. Install the shunt calibration resistor as follows:

   A. Select the appropriate shunt calibration resistor.

   B. Bend the resistor leads 90° for a 0.3 inch separation.

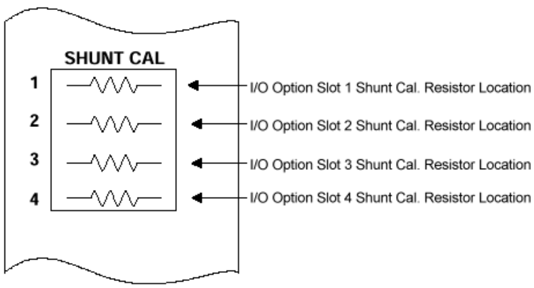
Calibration

C. Cut the resistor leads 0.12 inch from the bend.

D. Insert the resistor into the connector solder cups and solder.

E. Complete and attach a shunt calibration label as specified on the 493.40/41 Carrier I/O Shunt Calibration Kit (MTS PN 100-028-185).

F. Install the shunt cal resistor/connector assembly into the appropriate slot of the **SHUNT CAL** connector on the front panel of the appropriate I/O Carrier Module.



6. Perform shunt calibration.

A. In **Station Setup** select the appropriate strain channel on the navigation panel.**,** click the **Channel Input Signals** icon, and then click the **Shunt** tab.

B. Select the shunt type. Use (+) polarity if you are not sure what to select.

C. In the **Current Shunt Value** box, click the **On** button. Note the **Current Shunt Value**, it should be 60%–90% (80% is ideal) of the calibrated range of the sensor.

D. Click **Update** to copy the **Current Shunt Value** into the **Shunt Reference Value** box, and then click **Off**.

Task 9 Save the calibration settings

Click **Update File** on the **Calibration** tab to save the current calibration values to your current sensor calibration file.

Task 10 Calibrate any additional ranges

This task describes how to calibrate additional ranges. Each sensor calibration file can have calibration data for four ranges. If you have a need for additional ranges, create another sensor calibration range.

- Use the calibration values from the previous range as a starting point.
- If you adjust the zero reference, it may affect the other ranges.

Note *Some systems do not provide or require multiple ranges, such as those using full-range conditioners (e.g., Model 493.25 DUC module). In this case, only one range is used (typically 100%).*

Adding a range

If sensor calibration file must have additional ranges defined, perform the following:

1. Open the sensor file for the sensor you have just calibrated.
2. Click **Add** under **Range Definition**.
3. Select the units for the range, and then enter the absolute value of the range.
4. Save the new range to the calibration file.
5. Calibrate the added range.

Note *Ranges can also be added on the* ***Sensor*** *tab and calibrated on the* ***Calibration*** *tab.*

Chapter 7

Tuning

Tuning affects the response and stability of the servo-control loop. Proper tuning improves the performance of the system.

Note *Precise tuning is not necessary. A good tuning adjustment is one that produces near-optimal behavior over a wide variety of conditions.*

- Each control mode uses a different sensor feedback signal for servo-loop control. Each control mode must be tuned.
- Tuning optimizes test performance by minimizing the system error in the selected control mode.

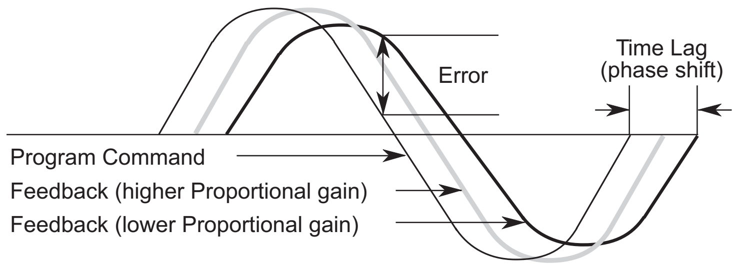
Contents

Tuning

About Tuning

When you tune, you are setting the stability and response of the servo control loop. Proper tuning improves the performance of the test system.

Proper tuning reduces error and phase lag.



Inaccurate tuning increases the error and phase lag between the program command and the sensor feedback. Large error reduces control accuracy and repeatability, and keeps the full program command from being applied to the specimen.

To make tuning easier, the Station Manager application includes an auto-tuning feature that automatically determines tuning values for PIDF control modes. This feature works well for most control modes.

If you prefer to tune manually, or want to optimize your current tuning values, you can use the manual tuning controls.

Compensating for specimen changes

Optimal system operation may require a level of detuning to compensate for specimen changes during a test.

- A highly tuned system provides the greatest level of response, but this places the system near the point of oscillation or instability.
- As a specimen changes characteristics during testing, the response of the system also changes. This can cause unstable operation.
- You may need to retune the system response when the characteristics of the specimen change during a test.
- For the greatest control accuracy, use a compensator.

If You’ve Never Tuned Before

If you are unfamiliar with the tuning controls, review the following guidelines. Before you start tuning you should:

- Define upper and lower limits for the displacement and force sensor before you start tuning.
- Tune the displacement control mode first since no specimen is needed.
- Note the value of the tuning control before adjusting it so you can return it to that value if necessary.
- Make small initial tuning adjustments. If the waveform does not appear to change, increase the adjustments.

Auto tuning provides a moderate level of tuning for PIDF control modes automatically. For more information, see “Auto tuning” on page 256.

What if you adjust something wrong?

If you make an inappropriate adjustment, the system will go unstable or shut down. An unstable system produces humming or screeching sound. A system shutdown displays an error.

- If an adjustment causes the system to go unstable, quickly readjust the control until the noise stops. If you cannot eliminate the sound, shut down the system by pressing the **Station Stop** or **Emergency Stop** switch.

Important ***In multi-station configurations, pressing Emergency Stop will shut down the HPU and all stations in the interlock chain. Pressing Station Stop on your Remote Station Controller shuts down the HSM for the specific station only.***

- If an adjustment causes the system to shut down, readjust the control to the level where the system was last stable. Then reset the system and continue tuning.

Saving the tuning parameters

The tuning values are saved as part of the controller parameter set. The parameter set can save one set of tuning values for each control mode.

When to Tune

Tuning is needed whenever any of the following events occurs:

- A gross change in the compliance or size of the test specimen. *For example*, you were testing steel and change to rubber.
- The servohydraulic configuration has changed. *For example*, a servovalve is replaced or changed to a different capacity.
- The system is sluggish (slow to react or not reaching the desired peaks). However, this is not always a tuning problem; it could be insufficient velocity capability such as a low-capacity servovalve.
- If a control channel or sensor is recalibrated.
- The system is unstable (indicated by a humming or screeching sound).
- When you observe poorly controlled accuracy.
- When you create a new control mode, or, if the sensor for a control mode is changed.
- The end levels or frequencies are significantly different from those observed earlier in the test. *For example*, you notice that the specimen characteristics change during the test (this could also mean the specimen is failing).

Checklist

Use this checklist when you tune a system. You need to determine the following:

- What type of control mode do you wish to tune?
  Read "Control Mode Characteristics" on page 236.
- What controls should you use?
  Read "How the Tuning Controls Work" on page 239.
- What kind of a tuning program should you use?
  Read "Creating a Tuning Program" on page 246.
- Do you have a dummy specimen?
  Read "Other Considerations" on page 249.
- Where do you connect the oscilloscope and what signal do you monitor? Read "Monitoring Waveforms" on page 250.

What to do first

The following are tasks that should be completed before you tune. It is not necessary to perform every task each time you tune. The condition of your system dictates which of the following tasks you must perform.

For example, a new system or a system under complete recalibration requires all of the following to be completed. If you are performing periodic or fine-tuning, review the following and determine which tasks you need to complete.

- Connect an oscilloscope to your system or use the controller scope. You need to monitor the sensor signal or error signal for the control mode you intend to tune. Go to “Monitoring Waveforms” on page 250 for help.
- Balance the servovalve. The electrical valve balance adjustment compensates for minor mechanical imbalance—it is an intermediate adjustment. Go to “Adjusting Valve Balance” on page 117 and perform the electrical valve balance adjustment procedure.
- Calibrate each sensor used for a control mode or data acquisition. Perform the appropriate calibration procedure.
- If your sensor calibration schedule does not require calibration at this time, perform a shunt calibration check to determine if your DC sensor/DC conditioner is within tolerance. See “Shunt Calibration” on page 136.
- If you have a three-stage (Series 256 or 257) servovalve, tune the inner loop (gain and rate) before tuning the outer loop. The rules for inner loop tuning are similar to those of the outer loop. Go to “Tuning the Inner loop” on page 119 for help.

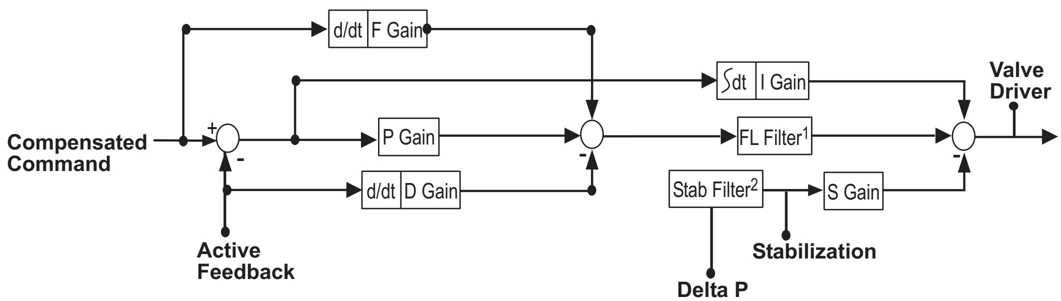
Getting started

When you set out to tune your system, it is best to run auto-tuning first. Auto-tuning establishes reasonable tuning levels that will be adequate for most control modes. See “Auto tuning” on page 256 for more information

If the results from auto-tuning are not satisfactory, you should create a tuning function, and then manually tune each control mode.

Control Mode Characteristics

A control mode uses a program command and sensor feedback to control the servovalve. The controller uses a group of gain controls—proportional, integral, derivative, and feed forward gain. These controls are called PIDF. The PIDF controller can also incorporate stabilization gain and an adjustable forward loop filter.



1 FL Filter on the Tuning Menu
Sets filter frequency and select filter type.

2 Stabilization Filter on the Tuning Menu
Sets filter frequency and select filter type.

Each control mode has different tuning characteristics. This section describes the characteristics of the following control modes:

- Displacement control
- Force control
- Strain control

Command sources

The program command source can come from an internal source (such as the **Function Generator** or the **MultiPurpose TestWare** application) or from an external device (such as an external profiler or function generator).

CLC control mode

Channel limited channel (CLC) control modes are used for specimen installation and removal. Channel limited channels require two feedback signals.

See "How to Tune a CLC Control Mode" in Chapter 5, Tuning of the Model 793.00 System Software Manual for a detailed CLC tuning procedure.

Displacement control

A length control mode (also called displacement or stroke control) uses the LVDT sensor in the actuator as the controlling feedback source.

- The length control mode only needs to be tuned once.
- Does not need a specimen installed for tuning.
- Displacement control uses a square wave when tuning an LVDT but not when tuning a displacement gage.
- If gain is too low, there may not be any actuator movement.
- If gain is too high, the actuator will move quickly and noisily.

Force control

Force control uses a force sensor (also called a load cell) as the controlling feedback source.

- Tune for each type of specimen or any changes in the force train.
- Force control requires a specimen to be installed.
- Force control uses a ramp waveform for the initial tuning. If the required results cannot be achieved, change to a square waveform.
- If gain is too low, the system may be sluggish or unresponsive with large static offsets.

Strain control

Strain control uses an extensometer or strain gage bonded to the specimen as the controlling feedback source.

- Tune for each type of specimen or any changes in the force train.
- Strain control requires a specimen to be installed (you may choose to use a broken specimen).
- Use a ramp waveform for the initial tuning.
- Do not use a square waveform for tuning. A square wave can cause the extensometer to move or fall off the specimen, which can cause the system to go unstable.
- If gain is too low, the system may be sluggish or unresponsive with large static offsets. Or, it may be uncontrollable.

How the Tuning Controls Work

The controller system software includes five tuning controls. You do not need to use all of the controls to properly tune your system. *In fact, most testing can be accomplished with just the proportional gain adjustment*. The other adjustments introduce a signal to the command to compensate for specific situations.

Note *Throughout this chapter the terms gain, rate, and reset represent proportional gain, rate derivative, and reset integration respectively.*

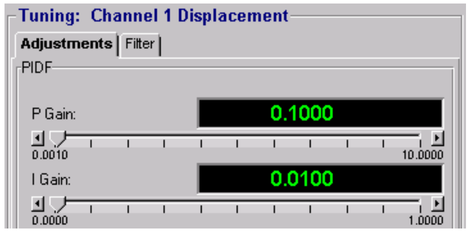
The five available tuning controls have the following functions:

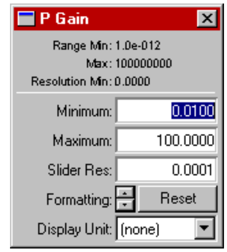
- Proportional gain (P Gain) increases system response.
- Integral gain (I Gain) increases system accuracy during static or low-frequency operation and maintains the mean level at high frequency operation.
- Derivative gain (D Gain) improves the dynamic stability when high proportional gain is applied.
- Feed forward gain (F Gain) increases system accuracy during high-frequency operation.
- Forward loop filter (FL Filter) adjustments establish a frequency bandwidth for the servoloop command signal.

Changing adjustment ranges

It is possible that the amount of adjustment for a control is too coarse or inadequate. Click the adjustment button (such as **P Gain**) and use the **Range Select** window to change the range of the adjustment. Reducing the range produces smaller steps between values (higher resolution) while increasing the range produces larger steps between values.

Example: Suppose the default range for the Proportional Gain adjustment is 50. Assume you are adjusting the gain and you reach the maximum adjustment (50). Clicking the **P Gain** slider label displays the **P Gain** range window where you can change the range of the adjustment. Change the range by typing a new value in the maximum entry field.

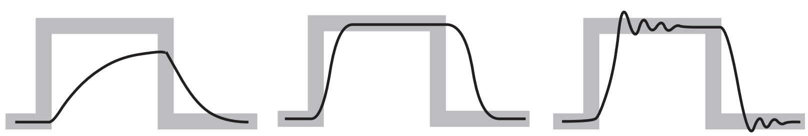




Proportional gain (P)

Proportional gain is used for all tuning situations. It introduces a control factor that is proportional to the error signal. Proportional gain increases system response by boosting the effect of the error signal on the servovalve.

The tuning command is shown as a gray square waveform, and the black waveform is the sensor feedback



Gain Too Low | Optimum Gain | Gain Too High

Keep in mind:

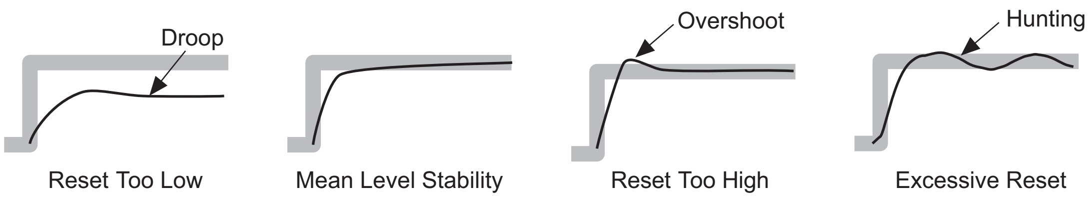
- As proportional gain increases, the error decreases and the feedback signal tracks the command signal more closely.
- Higher gain settings increase the speed of the system response.
- Too much proportional gain can cause the system to become unstable.
- Too little proportional gain can cause the system to become sluggish.
- Gain settings for different control modes may vary greatly. For example, the gain for force may be as low as 1 while the gain for strain may be as high as 10,000.

Note *The rule of thumb is—adjust gain as high as it will go without going unstable.*

Integral gain (I)

Integral gain introduces “an integral of the error signal” that gradually, over time, boosts the low-frequency response of the servovalve command.

Integral gain increases system response during static or low-frequency operation and maintains the mean level at high-frequency operation. It can offset a DC or steady-state error, such as that caused by valve imbalance.



A ramp and hold waveform illustrate different levels of reset. The **I Gain** adjustment determines how much time it takes to improve the mean level accuracy.

Integral gain:

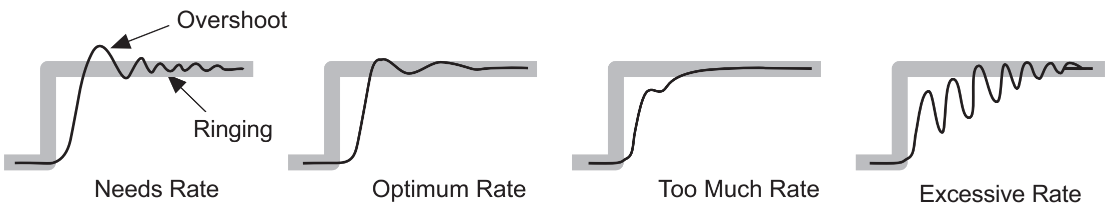
- Improves mean level response during dynamic operation
- Corrects feedback droop caused by the spring characteristic of the servovalve in static and very low-frequency test programs
- Minimizes the amount of time the system needs to recover from transitions or transients

Keep in mind:

- Higher integral gain settings increase system response.
- Too much integral gain can cause a slow oscillation (hunting).
- You may want to use the max/min display to monitor the mean level, reset the display, and check it again.

Derivative gain (D)

Derivative gain is used with dynamic test programs. It introduces a "derivative of the feedback signal." This means it anticipates the rate of change of the feedback and slows the system response at high rates of change.



Derivative gain:

- Reduces ringing
- Provides stability and reduces noise at higher proportional gain settings
- Tends to amplify noise from sensors
- Tends to decrease system response when set too high

Keep in mind:

- Too much derivative gain can create instability at high frequencies, and too much proportional gain may cause a ringing or screeching sound.
- Too little derivative gain can make a rumbling sound. The correct amount of derivative gain results in the system running quietly.

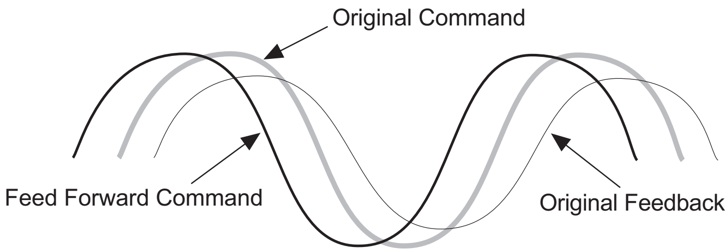
Note *Series 256 and 257 Servovalves may require derivative gain applied to both the inner control loop and outer control loop.*

Note *Excessive negative (–) D Gain can cause your system to become unstable.*

Feed forward gain (F)

Feed forward gain is like derivative gain except that it introduces a derivative of the command signal. It anticipates how much valve opening is needed to reach the required response and adds that to the valve command—like compensating for phase lag.

Adjusting feed forward causes the command to begin sooner so the feedback may track the original command more closely



Feed forward gain:

- Does not compensate for normal changes during testing (such as temperature changes, servovalve droop, and so forth).
- May be used to minimize phase lag.
- Should be used in a way similar to derivative gain. However, it is applied to the test command signal instead of the feedback signal. Feed forward gain helps the servo-control loop react quickly to an abrupt change in the command.
- Is needed when testing a soft specimen in force control.

Stabilization gain (S)

Stabilization gain allows a second signal to be integrated into the composite command signal as a stabilizing factor. It enhances stability for systems that move large masses at high speeds. The second signal is generated by a special transducer such as ΔP (differential pressure) or accelerometer.

Stabilization controls will be available only if a stabilization resource was added to the control channel in the Station Builder program.

Delta P (ΔP)

Delta P is a differential pressure sensor that measures the difference in pressure at each end of the actuator. It compensates for hydraulic compliance (compressed hydraulic fluid acts like a spring). Delta P improves displacement control of heavy mass loaded systems.

Delta P is typically used on systems with large hydraulic fluid flow rates. This adjustment is usually needed when the natural frequency of the actuator is less than the 90° phase lag frequency of the servovalve.

The servovalve 90° phase lag frequency can be found in the servovalve product literature.

The natural frequency can be approximated with the following formula:

$$\text{Actuator Frequency} = \frac{CA}{WV}$$

Where: C = constant for English (2500) or metric units (1060)

A = actuator piston area expressed as in^2 (cm^2)

W = any directly coupled mass including the actuator piston mass expressed in lbs (kg)

V = hydraulic fluid volume contained inside the actuator and manifold expressed as in^3 (cm^3)

- If the system response deteriorates when adding delta P, then change the polarity of the signal. If changing polarity does not improve system response, try adjusting the stabilization filter. See “Stabilization Filter” on page 245
- Check all amplitudes for overshoot. Do not allow more than 10% overshoot (preferably none) at any amplitude of a square wave response.
- Delta P will not compensate for additional compliance from swivels, linkages, test tables, and so forth. In this case, a mass accelerometer signal from an accelerometer may be used in place of a delta P signal for stabilization. See “Acceleration stabilization' below.

Acceleration stabilization

Test systems with specimens affected by acceleration resonances can use a mass accelerometer signal for stabilization. Acceleration stabilization dampens the resonances (vibrations) affecting the specimen.

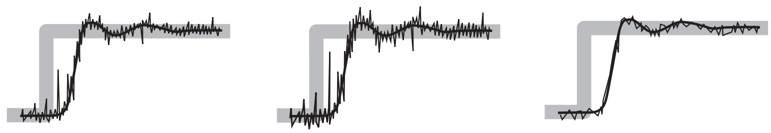
Typical systems that benefit from acceleration stabilization include:

- Load units that operate at high frequencies with massive grips
- Test systems that employ swivels, linkages, and test tables

Sensor feedback is provided by an accelerometer attached to (or near) the specimen. The controller converts this feedback into a stabilization signal which is combined with the composite command signal (post-PIDF correction). The “stabilized” command signal is then sent to the valve driver.

Forward loop filter (FL)

FL filter adjustments compensate for noise in the servoloop—which usually comes from sensor feedback. FL filter adjustments establish a frequency bandwidth for the servo-loop command signal.



Keep in mind:

- By default, the FL filter is set to one-half the system rate.
- The minimum FL filter frequency setting is 0.01.
- Be sure the forward loop filter frequency is higher than any frequency in the test program. (Most testing occurs below 50 Hz.)
- Systems with moving load cells or heavy grips can produce a noisy force signal.
- If you observe a noisy sensor feedback signal, reduce the FL filter setting to about 100 (providing your test does not reach 100 Hz). If additional adjustment is needed, reduce the setting by 5 - 10 Hz at a time.

Stabilization Filter

Some systems with a higher actuator frequency may benefit from changing the filter setting for the stabilization signal.

See “How to Enable a Tuning Filter” in Chapter 5, Tuning of the *Model 793.00 System Software* manual for a detailed procedure for changing the stabilization filter setting.

Creating a Tuning Program

The purpose of a tuning program is to produce a command that reflects the most demanding system response expected from a test.

Note *The **Function Generator** is very useful for quickly setting up a tuning program. If you use the same tuning program on a regular basis you may wish to create and save your tuning procedure using Basic TestWare™ or by using the optional MultiPurpose TestWare™ application.*

Initial tuning is best done with a waveform that has abrupt changes. This excites the system at frequencies likely to be unstable with excessive gain. Square and ramp waveforms are preferred. Final tuning can be done with the actual program command for the test.

Note *Always monitor the sensor feedback or error signal to evaluate the control accuracy. See "Monitoring Waveforms" on page 250.*

A typical tuning program is a low-amplitude (5% to 10% of full-scale), low-frequency (1 Hz to 2 Hz) square waveform.

This section describes how the amplitude, frequency, and waveform type of a tuning program can be selected to reflect the capabilities of the testing system or the testing requirements.

Auto tuning

Auto tuning provides a moderate level of tuning for PIDF control modes.

Auto tuning exercises the actuator (with a sweep function) while monitoring the feedback of the control mode being tuned. The response of the control mode is determined and the appropriate tuning parameters are calculated.

For more information, refer to "Auto tuning" on page 256.

Command waveforms

A tuning program produces a cyclic program command to exercise the system while you make the initial tuning adjustments. A square wave is best because it demands the maximum response of the servo hydraulic system. The square wave tuning program may not be suitable for all systems. The following describe the different waveform characteristics:

Square/Tapered Square

A square waveform requires the servovalve to open rapidly to a large opening. It is the most demanding waveform because it requires the maximum response from the servoloop system. It also places a large acceleration on the test system and specimen.

Tapered square waves taper from 0% to 100% amplitude at the beginning of execution, and from 100% to 0% at the end of execution.

- A square waveform is most useful for tuning displacement.
- A square waveform has an infinite velocity command.
- Do not use a square waveform when tuning a control mode that uses an extensometer. The large accelerations can cause the extensometer to move or fall off the specimen, which can cause the system to go unstable.
- Monitor the feedback or error signal to evaluate the system stability.

Ramp/Tapered Ramp

A ramp waveform (also called a triangle waveform) requires the actuator to move at a constant rate. This requires the servovalve to move quickly between two discrete openings. Cycling a ramp waveform produces a triangle waveform.

Tapered ramp waves taper from 0% to 100% amplitude at the beginning of execution, and from 100% to 0% at the end of execution.

- A ramp waveform is useful for all levels of tuning.
- Use a ramp waveform if a square waveform creates excessive velocities or acceleration for the type of specimen being tested.
- Monitor the feedback or error signal to evaluate the system stability.

Sine/Tapered Sine

A sine waveform (also called sinusoidal or haversine) requires the servovalve to move at a variety of rates.

Tapered sine waves taper from 0% to 100% amplitude at the beginning of execution, and from 100% to 0% at the end of execution.

- Monitor the feedback or error signal to evaluate the system stability.

Random function generator

When tuning AIC compensator configurations, it is necessary to generate random functions to properly simulate typical test conditions.

Random functions employ a pre-emphasis filter to make the convergence rate constant over all frequencies. The random function options include:

- Random - $1/F^2$
- Random - 1/F
- Random - Flat (none)
- Random - F
- Random - F^2

Frequency

A low-frequency waveform is adequate for most testing. Tests at higher frequencies cause a frequency shift that cannot be completely corrected with the PIDF adjustments.

- Do your initial tuning at a low frequency, and then fine tune at the highest frequency in your test program. Common values are 1–2 Hz.
- Servo adjustments that do not improve performance at high frequencies generally indicate that the servovalve is running at 100% capacity or the HPU is running at 100% capacity.

This characteristic can easily be seen when tuning with a sine waveform. The feedback waveform appears to be more like a ramp waveform when running at 100% capacity.

Amplitude

A system tuned at a low amplitude may become unstable at high amplitudes. Tuning should be accomplished under conditions similar to the anticipated usage.

- Use a moderate amplitude (5% to 10% full scale) for initial tuning.
- Be sure the maximum velocity of the tuning command is 10% to 50% of the maximum velocity of the system.
- Increase the amplitude for fine tuning.
- You may find it helpful to check tuning over a variety of amplitudes by creating a test that cycles once at each of the target amplitudes. If you have the optional MultiPurpose TestWare™ application, run the test to acquire timed data so you can evaluate the results for each amplitude.

Other Considerations

Servovalves

Most of the servovalve adjustments are performed during the system installation and do not require periodic adjustment. There are two types of servovalves:

- Three-stage servovalves, such as the MTS Series 256 and 257 Servovalves, have an inner loop control system which must be tuned before the outer loop can be tuned.
- Two-stage servovalves, such as the MTS Series 252 Servovalves, do not have inner loop tuning requirements.

After initial system tuning and before final tuning, the valve balance should be checked and adjusted if necessary.

Using specimens

Specimens can be very expensive. A dummy specimen is an inexpensive material that has similar characteristics to the specimen selected for testing. The most important specimen characteristic is its spring rate.

The advantage of a dummy specimen is that it can simulate how your testing system reacts to real specimen. You can establish a more precise level of tuning with a dummy specimen.

Tuning without dummy specimens

If you do not have a dummy specimen or if a dummy specimen is not practical, review the following recommendations if you must use a real specimen:

- Start your PIDF controls at minimum settings.
- Do not use a square waveform for a massive specimen or a specimen prone to vibrations.
- Adjust rate to minimize any oscillation, overshoot, or ringing in the waveform.
- Be very conservative by beginning with a ramp waveform to establish initial control. Then use a waveform that resembles the test waveform to provide a precise level of control.

Tuning without a specimen

A specimen is required to tune force and strain control modes. Initial force tuning may be accomplished with the actuator up against the force sensor. The actuator acts as a specimen reacting against the force sensor. Review the following recommendations if you must tune without a specimen:

- If you are using a load frame, adjust the load unit crosshead so the actuator can reach the force sensor.
- Carefully adjust the actuator using a tuned length control mode so it contacts the force sensor.
- Switch to force control before you proceed with initial tuning.

Monitoring Waveforms

When you tune the servoloop you need to monitor the results of your adjustments. There are two ways to monitor a waveform during tuning.

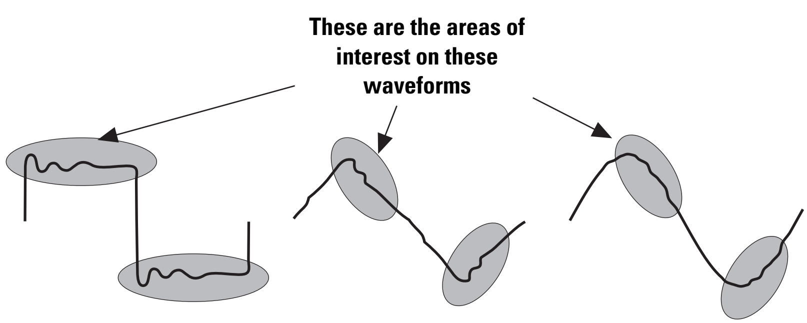
- An oscilloscope is preferred.
- The controller scope is adequate if you do not have an oscilloscope.

Note *Set up your scope to monitor the area of the waveform that shows characteristics useful for tuning. You can monitor the sensor feedback or the error signal of the control mode.*

What to monitor

The accuracy of the waveform represents how well it reaches the amplitude of the command or how repeatable the end levels are. The peaks and valleys of triangle and sine waveforms should be consistent. Use the area of the square wave after the ringing settles to monitor the end levels.

You do not need to monitor the entire waveform. Instead, zoom in on the area of interest.



If the amplitude of the feedback cannot be achieved without going unstable, and the end levels are repeatable, simply increase the command to achieve the desired end levels.

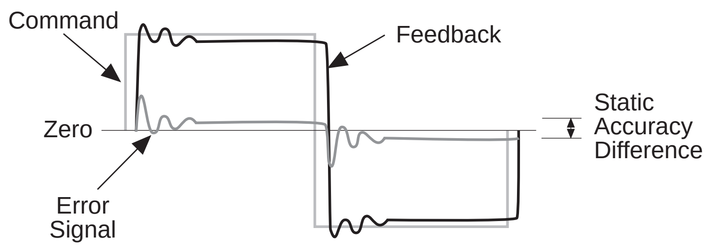
Monitoring the error signal

The error signal shows similar characteristics as a feedback signal. The error signal represents the difference between the command and sensor feedback. The following diagrams show the error signal characteristics for each type of waveform.

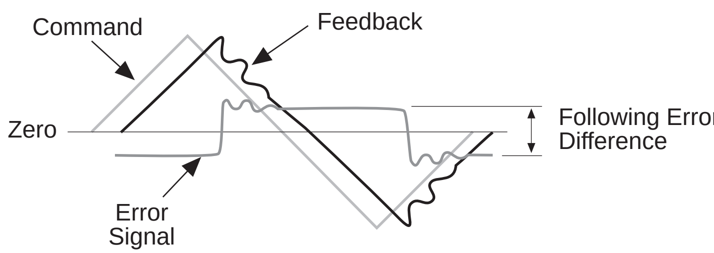
A square waveform is best suited to view the overshoot and ringing characteristics that occur when tuning a system. Review the following waveforms to determine the kind of characteristics that can be found in an error signal.

The error signal from a square wave should show the feedback ringing centered on the zero reference.

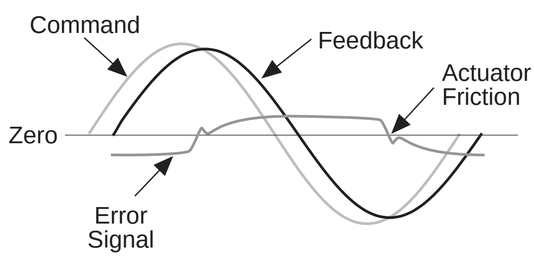
A static accuracy difference in the error signal can be corrected with reset.



The square wave shape of the error signal represents the phase lag of the feedback signal.



The error signal from a sine should be a small amplitude sine waveform that looks like a rounded square waveform.



Using the controller scope

If you do not have an oscilloscope, use the controller scope feature for tuning control modes. Review the following:

- Select **Scope** on the Station Manager **Display** menu.
- Select a continuous sweep.
- Enter the minimum and maximum ranges on the Y axis to zoom into the area of interest.

For more information on the controller scope, refer to the *Model 793.00 System Software* manual.

Using an oscilloscope

An oscilloscope has a higher resolution and is faster than the software controller scope. Review the following:

- You must have a Readout channel defined in the Station Builder.
- Set up the Readout channel in the Station Manager program to monitor the sensor signal of the control mode you intend to tune.
- Or, you could monitor the error signal. You can tune using either signal.
- Connect the oscilloscope to the appropriate BNC connector on the Analog Out transition module (**Ch 1 - Ch 6**) located at the rear panel of the Model 493.10 Chassis.

Tuning Displacement

A displacement control mode uses the feedback signal from an LVDT (linear variable differential transformer). You do not need a specimen to tune a displacement control mode.

When to tune

A displacement control mode usually only needs to be tuned once.

However, you may want to retune a displacement control mode if:

- The fixtures attached to the actuator have changed (such as grips). The main tuning factor is a change in the mass attached to the actuator.
- Any time hydraulic system potential has changed, such as after servovalve, hose, or pump replacement.
- You want to fine tune the control mode.
- The LVDT ranges are changed.
- You deem it necessary as a result of scheduled system calibration or you feel system response should be improved or reduced.

Prerequisites

Be sure the following items are completed before you begin tuning the displacement control mode:

- Hydraulic pressure is off.
- The specimen is not installed.
- You have created a station configuration file.
- You have created a station parameter set.

Tuning procedure

Refer to "Tuning Displacement" in Chapter 5, Tuning of the *Model 793.00 System Software* manual for a detailed tuning procedure.

Tuning Force

To complete this task, you will make sure the force tuning values established in your station parameter set are appropriate for the test you are about to run. To do this, you will:

- Create and apply a simple tuning program.
- Evaluate the current force tuning values by comparing command and feedback signals.

The displacement tuning values established in the station parameter set are unlikely to require adjustment. Optimal force tuning values, however, are a function of your specimen's compliance, which may change over time, or from test-to-test. You should also tune force whenever you make any change to the force train (such as changing fixtures).

Prerequisites

Be sure the following items are done before you begin tuning the force control mode:

- Hydraulic pressure is off.
- The specimen is not installed.
- You have created a station configuration file.
- You have created a station parameter set.

Tuning procedure

Refer to "Tuning Force" in Chapter 5, Tuning of the *Model 793.00 System Software* manual for a detailed tuning procedure.

Auto tuning

Purpose

The auto tuning feature automatically calculates tuning values for PIDF control modes.

Note *Auto tuning is only available for PIDF control modes.*

How auto tuning works

There are two levels of auto tuning, **Basic** and **Advanced**.

The **Basic** auto tuner disregards your current PIDF gain settings. It applies the minimum required drive signal to ramp the feedback to 80% of the auto tuning limits. It then measures the relationship between the feedback velocity and the valve opening, and derives the minimum PIDF gains required to track the command.

The majority of tests will run adequately with the settings calculated through basic auto tuning, however, advanced auto tuning may be used to optimize the results obtained through basic auto tuning.

The **Advanced** auto tuner performs basic auto tuning, and then uses a sine sweep to exercise the actuator to 20% of the auto tuning limits with frequencies between 0.5 Hz and 20 Hz (the upper frequency is user-definable).

Note *The advanced auto tuner will reduce the sweep amplitude if it detects the valve opening more than 50%.*

The advanced tuner calculates the tuning parameters according to the tracking level you define. In order to achieve a successful level of advanced auto tuning, the sine sweep must create a phase shift (between the command and compensated command) of more than 90° for 0% tracking, or more than 135° for 100% tracking. You can monitor the advanced tuner command and compensated command on the scope.

Accepting the auto tuning values

The **Current** column displays your current PIDF gain values. When auto tuning completes successfully, the calculated tuning parameters are loaded into the **New Values** column on the **Auto-Tuning** control panel.

You can click **Accept** to transfer the auto-tuned values (**New Values**) to the **Current** column and the tuning **Adjustments** tab.

How to Auto-Tune Control Modes

First, auto-tune the displacement control mode. Then install a dummy specimen and auto-tune the force control mode.

Auto-tune the displacement control mode

See “How to Auto-Tune Control Modes” in Chapter 5, Tuning of the *Model 793.00 System Software* manual for a detailed procedure.

Auto-tune the force control mode

See “How to Auto-Tune Control Modes” in Chapter 5, Tuning of the *Model 793.00 System Software* manual for a detailed procedure.

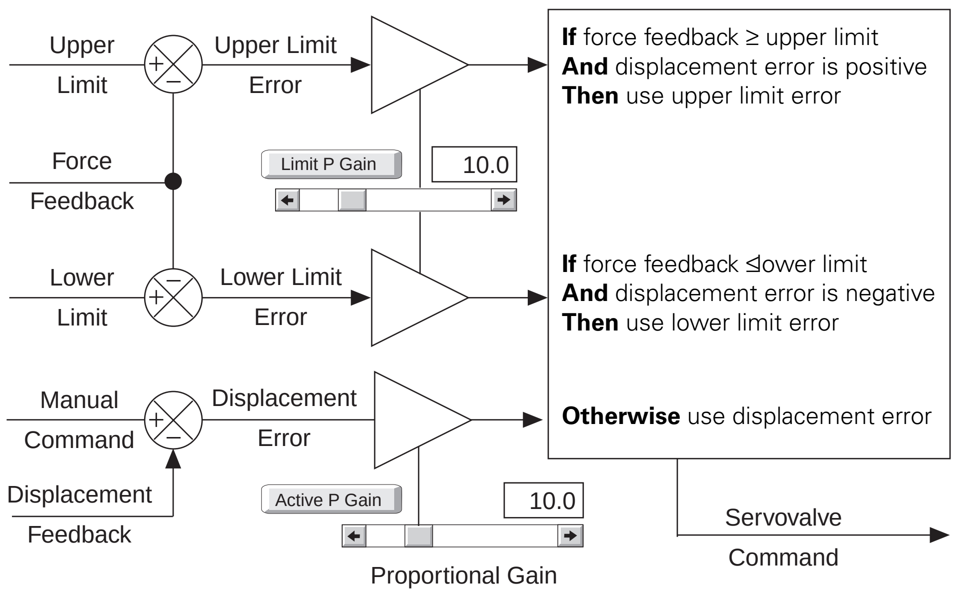
How to improve auto-tuning results

You can attempt to further improve tuning using the following techniques:

- If you are running **Advanced** auto-tuning, increase the **Tracking%** to make the feedback track the command more closely.
- Use the auto-tuning settings as a starting point when manually tuning each control mode.
- If your feedback signal is noisy, use a tuning filter.

Tuning a CLC Control Mode

CLC control modes are used for specimen installation and removal. Channel limited channels require two feedback signals. The first one is used as the master feedback (it is normally displacement) and the second one is used as the limiting feedback (it is normally force). When you command the actuator over a channel limited channel, the controller will not allow the actuator to exceed limits specified on either the master or limiting channels.



The CLC control mode uses one of three error signals. The **Limiting P Gain** adjustment acts as a conversion factor to scale the limit feedback to similar units as the active P feedback.

Tuning Procedure

Refer to “How to Tune a CLC Control Mode” in Chapter 5, Tuning of the Model 793.00 System Software Manual for a detailed CLC tuning procedure.

Appendix A

Hydraulic Configurations

This section describes how to connect the Model 493.10 Chassis to a variety of MTS hydraulic configurations.

You will use the following connectors and cables to connect the Model 493.10 Chassis to your HPU:

493 Chassis to 493.07 Pump Interface

- 15 contact type D female EMI connector at **J25** of the 493.73 HPU Transition module in the rear panel of the Model 493.10 Chassis. Backshell–EMI metallized plastic.
- 14 contact type CPC male connector at **J1** of the 493.07 Pump Interface chassis.
- Cable–24 AWG 10 conductor with overall foil shield, (Carol C0745 or equivalent) with drain wire connected to metallized plastic backshell at the 493.10 chassis, and pin 14 at the 493.07 Pump Interface chassis.

493.07 Pump Interface to HPU

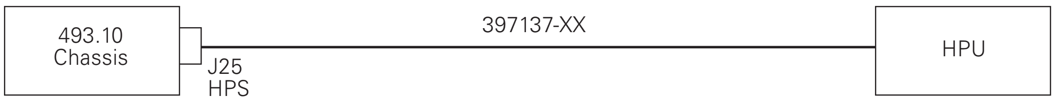
- 24 contact type CPC female connector at J25 of the 493.07 Pump Interface chassis.
- 14 contact type MS connector at J1 of the HPU.
- Cable–18 AWG 14 conductor with overall foil shield, (Alpha 2248C or equivalent) with drain wire connected to pin 4 of connector J25 and pin A of the pump connector.

Hydraulic pump configurations

The following diagrams show how to connect the chassis to a hydraulic power unit.

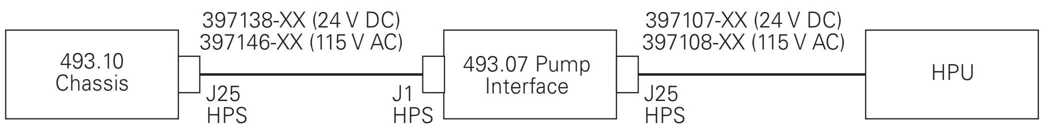
- Single 493 chassis with a 24 V PLC (programmable logic controller) pump or 505 pump
- Single 493 chassis with a non-PLC pump
- Multiple 493 chassis with a non-PLC pump
- Compatible controllers controlling a pump

Single 493 Chassis with a 24 V PLC pump (506.52-.92) or 505 pump

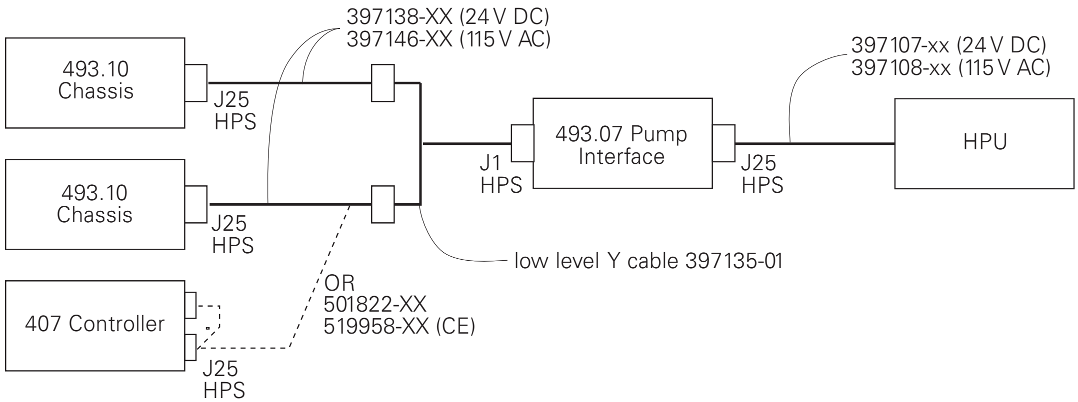


Note *The following three configurations have cables to support both 24 V DC and 115 V AC control voltages. A 493.07 Pump Interface is available for each voltage (not both). Be sure the cables and pump interface are rated for the same voltage.*

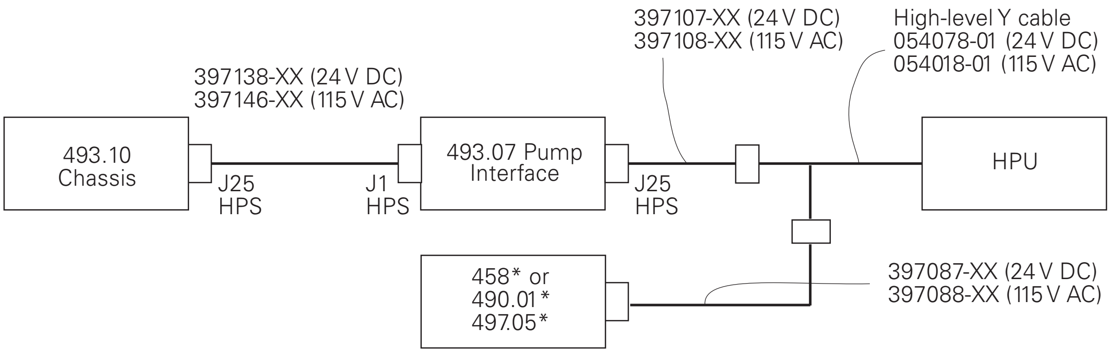
Single 493 Chassis with a non-PLC pump



Multiple 493 Chassis and 407 Controllers



Compatible Controllers



* For standard 493.07 jumper setting only. Alternate settings are required for 436.11 and 413.05 controllers.

You can mix 493.07, 458, 490. and 497.05 controllers directly on the same HPU (without the use of an HPU isolation box).

You cannot mix 493.07, 458, 490. and/or 497.05 controllers with 436, 413.05, or 413.8X controllers unless you use an isolation box.

You can jumper the 493.07 converter box so you can use it directly with 436 and 413.05 controllers. However, if you do this you must use an isolation box if you attempt to mix the 493.07 with 458, 490, and 497.05 controllers. See Appendix B, "Model 493.07 Pump Interface" on page 263

Hydraulic Configurations

Appendix B

Model 493.07 Pump Interface

The 493.07 Pump Interface (PN 499694-xx) is designed to connect the 493.10 chassis to a hydraulic power unit (HPU) such as MTS Model 506 HPU or equivalent relay-operated pump. The pump interface converts logic-level signals to and from the 493.10 chassis to relay signals used by the HPU pump.

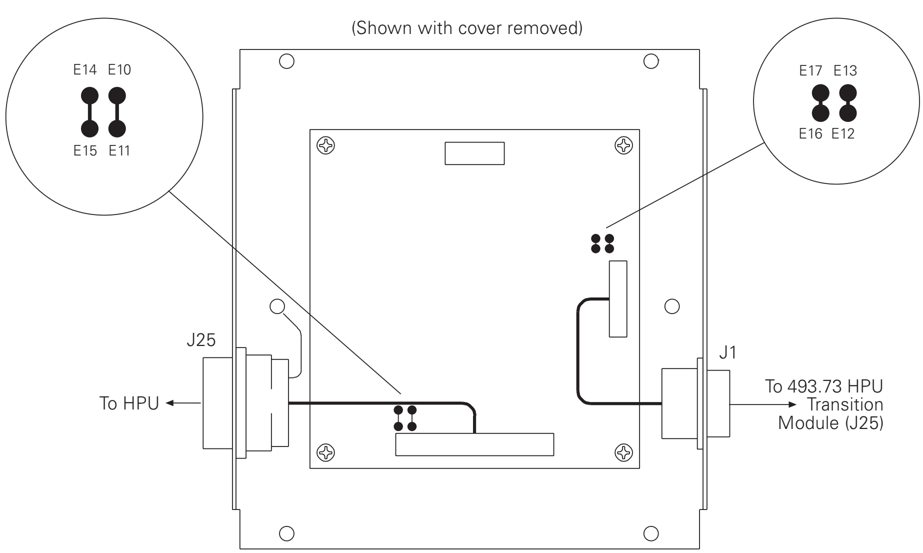
For pumps that are 24V PLC compliant, the pump interface is not needed. This includes all Series 505 HPUs and 506.52-.92 HPUs.

CAUTION

You must have the Model 493.07 Pump Interface designed for the correct voltage before installation. Connecting a 24 V interface box to a 115 V (AC) HPU causes improper operation.

Be sure the voltage marked on the cover of the 493.07 Pump Interface matches the required voltage for the hydraulic power unit.

The following figure shows the main components of the 493.07 Pump Interface, including connectors and jumpers.



CAUTION

Disconnect all cables from the Model 493.07 Pump Interface before removing the cover. Failure to do so could expose the operator to dangerous voltages.

If the Pump Interface remains connected to a 120 volt HPU, this voltage will be present. Always remove all cable before removing the cover.

Jumper configurations

As shipped, the HPU interface on the 493.07 Pump Interface is compatible with 458.10/.20, 490.01 (TestStar II), 493.xx, and 497.05 controllers.

The 493.07 Pump Interface may be connected to other controllers (as shown in the following table) using a "Y" cable.

Note *If the 493.10 chassis is the only device connected to the HPU, the jumper settings do not matter.*

COMPATIBLE WITH	JUMPERS
Model 458.05/.10/ .20/.40 **Model 490.01** **Model 497.05**	**Standard jumper setting:** **E10–E11install** **E12–E13 install** **E14–E15install** **E16–E17install** **E10–E13 remove** **E14–E17 remove**
Model 413.05 **Model 436.11** **Model 407.05**	**Jumper change required:** **E10–E11 remove** **E12–E13 remove** **E14–E15 remove** **E16–E17 remove** **E10–E13 install** **E14–E17 install**

Note *The Model 493.07 Pump Interface can not be compatible with both groups of controllers at the same time. If this functionality is needed, use an HPU isolation box.*

Appendix C

Maintenance

This section describes how to maintain the Model 493.10 Chassis.

Cleaning the chassis

Remove any dust from the chassis with Endust™ for Electronics or equivalent.

Cleaning the air filter

Be sure the cooling fan is operational and not clogged. Clean or replace the filter as required. The filter is located in the top of the chassis (stand-alone version). It can be accessed from the rear of the chassis. Slide the filter out from the top of the transition modules.

Note *The filter has a top and a bottom. be sure you re-install the filter in the proper orientation.*

Clean the air filter with soapy water, and then dry it completely.

Appendix D

Optional Station Configurations

This section describes how to configure your Model 493.10 Chassis to support an optional six or eight stations.

When configuring your system for a six or eight stations you must consider the following:

- Ensure that the .hwi file is correctly set for the desired multi-station configuration, especially the interlock and HSM board settings.
- Power to each HSM is limited.
- Cross-head interlocks with solenoid power are not supported.
- Remote Station Control (RSC) is not supported.
- AC input power must be at least 115 V AC.
- Auxiliary power out of J49 on the Model 493.74 HSM Transition board is not supported.

See "The .HWI File" on page 283 for more information on setting up your .hwi file

6-Station Configuration

The 6-station configuration can provide either six or eight channels of control.

A typical 6-channel/6-station configuration requires 12 Digital Universal Conditioners and 6 two-stage valve drivers.

A typical 8-channel/6-station configuration requires 16 Digital Universal Conditioners and 8 two-stage valve drivers.

HSM power limits

HSM power current is limited to 1.5 A per HSM.

Interlocks

For 6-station configurations the .hwi file must contain the line **INTERLOCKS=6**. This line must be a discrete entry, not part of any other .hwi section.

Cross-head interlocks with solenoid power are not supported for 6-station configurations.

RSC

Remote Station Control (RSC) is not supported for 6-station configurations.

.HWI file

This is an example of a ftgt.hwi file that defines resources for a 6-station, 6-channel FlexTest GT system. This system includes standard hardware, including:

- five 2-stage valve drivers
- One 3-stage valve driver
- One A/D daughter board
- One D/A daughter board
- Twelve Universal Conditioners (6 AC and 6 DC)

The file listing

The following is an actual ftgt.hwi file:

```
/* Both processor entries are needed for single processor systems. */
PROCESSOR
 ADDRESS=0xC8000000
 SLOT=1
 FUNCTION=SUPERVISOR
 PROCESSOR NUMBER=0
 INTERRUPT LEVEL=2
 FILENAME="tsiismcsup.o"
 PORT=ETHERNET
 IP ADDRESS="148.150.203.191"

PROCESSOR
 ADDRESS=0x00000
 SLOT=1
 FUNCTION=CONTROL
 PROCESSOR NUMBER=1
 INTERRUPT LEVEL=5
 FILENAME="tsiismcdsp.o"
 SHARED MEMORY=0x700000

SYSTEM OPTIONS
  /*VELOCITY LIMITER*/

INTERLOCKS=6

HPU TRANSITION BOARD
 TRANSITION SLOT = 9
 NAME = "HPU"
 MAIN POWER = TRUE
 FIRST ON = TRUE
 LAST OFF = TRUE
 VISIBLE = TRUE
 CONNECTOR = "J25"

HSM TRANSITION BOARD
 TRANSITION SLOT = 8
 CHANNEL 1 NAME = "HSM 1" CONNECTOR = "J28A" CONNECT TO
MAIN = TRUE TYPE = SOLENOID
 CHANNEL 2 NAME = "HSM 2" CONNECTOR = "J28B" CONNECT TO
MAIN = TRUE TYPE = SOLENOID
```

```
HSM TRANSITION BOARD
 TRANSITION SLOT = 6
 CHANNEL 1 NAME = "HSM 3" CONNECTOR = "J28A" CONNECT TO
MAIN = TRUE TYPE = SOLENOID
 CHANNEL 2 NAME = "HSM 4" CONNECTOR = "J28B" CONNECT TO
MAIN = TRUE TYPE = SOLENOID

HSM TRANSITION BOARD
 TRANSITION SLOT = 4
 CHANNEL 1 NAME = "HSM 5" CONNECTOR = "J28A" CONNECT TO
MAIN = TRUE TYPE = SOLENOID
 CHANNEL 2 NAME = "HSM 6" CONNECTOR = "J28B" CONNECT TO
MAIN = TRUE TYPE = SOLENOID

IO CARRIER
 ADDRESS=0xC2000000
 SLOT=3
 CLOCK MODE=BINARY
 SYSTEM RATE=2048
 MEDIUM SYSTEM RATE = 256.0
 LOW SYSTEM RATE = 25.6
 CLOCK TYPE = MASTER

 DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 1 NAME="493.25 DC-Slot 3-1" CONNECTOR="J4"
MODE=DC FILTER=300

 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 2 NAME="493.25 AC-Slot 3-2" CONNECTOR="J5"
MODE=AC FILTER=300

 DAUGHTER 3 ADDRESS=0x20000 TYPE=#493.45
FILENAME="A2D_53.OUT"
   CHANNEL 3 NAME="Analog Input 1-Slot 3-3" CONNECTOR="J6"
   CHANNEL 4 NAME="Analog Input 2-Slot 3-3" CONNECTOR="J6"
   CHANNEL 5 NAME="Analog Input 3-Slot 3-3" CONNECTOR="J6"
   CHANNEL 6 NAME="Analog Input 4-Slot 3-3" CONNECTOR="J6"
   CHANNEL 7 NAME="Analog Input 5-Slot 3-3" CONNECTOR="J6"
   CHANNEL 8 NAME="Analog Input 6-Slot 3-3" CONNECTOR="J6"
```

```
 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT"
  CHANNEL 1 NAME="493.14 2SVD-Slot 3-4" CONNECTOR="J7"
RANGE=25 MODE=SINGLE CLAMP=DISABLED

IO CARRIER
 ADDRESS=0xC2200000
 SLOT=4
 CLOCK TYPE = SLAVE

 DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 1 NAME="493.25 DC-Slot 4-1" CONNECTOR="J4"
MODE=DC FILTER=300

 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 2 NAME="493.25 AC-Slot 4-2" CONNECTOR="J5"
MODE=AC FILTER=300

/* Daughter 3 is empty and used for optional boards */

 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.15
FILENAME="D3VD_53.OUT"
  CHANNEL 1 NAME="493.15 3SVD-Slot 4-3" CONNECTOR="J7"
CLAMP=DISABLED

IO CARRIER
 ADDRESS=0xC2400000
 SLOT=5
 CLOCK TYPE = SLAVE

 DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 1 NAME="493.25 DC-Slot 5-1" CONNECTOR="J4"
MODE=DC FILTER=300

 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 2 NAME="493.25 AC-Slot 5-2" CONNECTOR="J5"
MODE=AC FILTER=300
```

```
 DAUGHTER 3 ADDRESS=0x20000 TYPE=#493.46
FILENAME="D2A_53.OUT"
   CHANNEL 1 NAME="Analog Output 1-Slot 5-3" CONNECTOR="J6"
   CHANNEL 2 NAME="Analog Output 2-Slot 5-3" CONNECTOR="J6"
   CHANNEL 3 NAME="Analog Output 3-Slot 5-3" CONNECTOR="J6"
   CHANNEL 4 NAME="Analog Output 4-Slot 5-3" CONNECTOR="J6"
   CHANNEL 5 NAME="Analog Output 5-Slot 5-3" CONNECTOR="J6"
   CHANNEL 6 NAME="Analog Output 6-Slot 5-3" CONNECTOR="J6"

 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT"
  CHANNEL 7 NAME="493.14 2SVD-Slot 5-4" CONNECTOR="J7"
RANGE=25 MODE=SINGLE CLAMP=DISABLED

IO CARRIER
 ADDRESS=0xC2600000
 SLOT=6
 CLOCK TYPE = SLAVE

DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 1 NAME="493.25 DC-Slot 6-1" CONNECTOR="J4"
MODE=DC FILTER=300

 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 2 NAME="493.25 AC-Slot 6-2" CONNECTOR="J5"
MODE=AC FILTER=300

 /* Daughter 3 is empty and used for optional boards */

 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT"
  CHANNEL 1 NAME="493.14 2SVD-Slot 6-4" CONNECTOR="J7"
RANGE=25 MODE=SINGLE CLAMP=DISABLED

IO CARRIER
 ADDRESS=0xC2800000
 SLOT=7
 CLOCK TYPE = SLAVE

DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 1 NAME="493.25 DC-Slot 7-1" CONNECTOR="J4"
MODE=DC FILTER=300
```

```
 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 2 NAME="493.25 AC-Slot 7-2" CONNECTOR="J5"
MODE=AC FILTER=300

 /* Daughter 3 is empty and used for optional boards */

 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT"
  CHANNEL 1 NAME="493.14 2SVD-Slot 7-4" CONNECTOR="J7"
RANGE=25 MODE=SINGLE CLAMP=DISABLED

IO CARRIER
 ADDRESS=0xC2A00000
 SLOT=8
 CLOCK TYPE = SLAVE

DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 1 NAME="493.25 DC-Slot 8-1" CONNECTOR="J4"
MODE=DC FILTER=300

 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 2 NAME="493.25 AC-Slot 8-2" CONNECTOR="J5"
MODE=AC FILTER=300

 /* Daughter 3 is empty and used for optional boards */

 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT"
  CHANNEL 1 NAME="493.14 2SVD-Slot 8-4" CONNECTOR="J7"
RANGE=25 MODE=SINGLE CLAMP=DISABLED


DIO TRANSITION BOARD
 TRANSITION SLOT=10
 CONNECTOR = "J3"
  INPUT 1 NAME="Digital Input 1"
  INPUT 2 NAME="Digital Input 2"
  INPUT 3 NAME="Digital Input 3"
  INPUT 4 NAME="Digital Input 4"
  INPUT 5 NAME="Digital Input 5"
  INPUT 6 NAME="Digital Input 6"
```

```
 INPUT 7 NAME="Digital Input 7"
 INPUT 8 NAME="Digital Input 8"
 INPUT 9 NAME="Digital Input 9"
 INPUT 10 NAME="Digital Input 10"
 INPUT 11 NAME="Digital Input 11"
 INPUT 12 NAME="Digital Input 12"
 INPUT 13 NAME="Digital Input 13"
 INPUT 14 NAME="Digital Input 14"
 INPUT 15 NAME="Digital Input 15"
 INPUT 16 NAME="Digital Input 16"
CONNECTOR="J4"
 OUTPUT 1 NAME="Digital Output 1"
 OUTPUT 2 NAME="Digital Output 2"
 OUTPUT 3 NAME="Digital Output 3"
 OUTPUT 4 NAME="Digital Output 4"
 OUTPUT 5 NAME="Digital Output 5"
 OUTPUT 6 NAME="Digital Output 6"
 OUTPUT 7 NAME="Digital Output 7"
 OUTPUT 8 NAME="Digital Output 8"
 OUTPUT 9 NAME="Digital Output 9"
 OUTPUT 10 NAME="Digital Output 10"
 OUTPUT 11 NAME="Digital Output 11"
 OUTPUT 12 NAME="Digital Output 12"
 OUTPUT 13 NAME="Digital Output 13"
 OUTPUT 14 NAME="Digital Output 14"
 OUTPUT 15 NAME="Digital Output 15"
 OUTPUT 16 NAME="Digital Output 16"
```

8-Station Configuration

The 8-Station configuration can provide eight channels of control.

A typical 8-Channel/8-Station configuration requires 16 Digital Universal Conditioners and 8 two-stage valve drivers.

HSM power limits

HSM power current is limited to 1.5 A per HSM.

Interlocks

For 8-station configurations the .hwi file must contain the line **INTERLOCKS=8**. This line must be a discrete entry, not part of any other .hwi section.

Cross-head interlocks with solenoid power are not supported for 8-station configurations.

RSC

Remote Station Control (RSC) is not supported for 8-station configurations.

A/D analog inputs

Only one set of six A/D analog inputs is supported for 8-station configurations.

.HWI settings

This is an example of a ftgt.hwi file that defines resources for an 8-station, 8-channel FlexTest GT system. This system includes standard hardware, including:

- seven 2-stage valve drivers
- One 3-stage valve driver
- One A/D daughter board
- One D/A daughter board
- Sixteen Universal Conditioners (8 AC and 8 DC)

The file listing

The following is an actual ftgt.hwi file:

```
/* Both processor entries are needed for single processor systems. */
PROCESSOR
 ADDRESS=0xC8000000
 SLOT=1
 FUNCTION=SUPERVISOR
 PROCESSOR NUMBER=0
 INTERRUPT LEVEL=2
 FILENAME="tsiismcsup.o"
 PORT=ETHERNET
 IP ADDRESS="148.150.203.191"

PROCESSOR
 ADDRESS=0x00000
 SLOT=1
 FUNCTION=CONTROL
 PROCESSOR NUMBER=1
 INTERRUPT LEVEL=5
 FILENAME="tsiismcdsp.o"
 SHARED MEMORY=0x700000

SYSTEM OPTIONS
  /*VELOCITY LIMITER*/

INTERLOCKS=8

HPU TRANSITION BOARD
 TRANSITION SLOT = 9
 NAME = "HPU"
 MAIN POWER = TRUE
 FIRST ON = TRUE
 LAST OFF = TRUE
 VISIBLE = TRUE
 CONNECTOR = "J25"

HSM TRANSITION BOARD
 TRANSITION SLOT = 8
 CHANNEL 1 NAME = "HSM 1" CONNECTOR = "J28A" CONNECT TO
MAIN = TRUE TYPE = SOLENOID
 CHANNEL 2 NAME = "HSM 2" CONNECTOR = "J28B" CONNECT TO
MAIN = TRUE TYPE = SOLENOID
```

```
HSM TRANSITION BOARD
 TRANSITION SLOT = 6
 CHANNEL 1 NAME = "HSM 3" CONNECTOR = "J28A" CONNECT TO
MAIN = TRUE TYPE = SOLENOID
 CHANNEL 2 NAME = "HSM 4" CONNECTOR = "J28B" CONNECT TO
MAIN = TRUE TYPE = SOLENOID

HSM TRANSITION BOARD
 TRANSITION SLOT = 4
 CHANNEL 1 NAME = "HSM 5" CONNECTOR = "J28A" CONNECT TO
MAIN = TRUE TYPE = SOLENOID
 CHANNEL 2 NAME = "HSM 6" CONNECTOR = "J28B" CONNECT TO
MAIN = TRUE TYPE = SOLENOID

HSM TRANSITION BOARD
 TRANSITION SLOT = 2
 CHANNEL 1 NAME = "HSM 7" CONNECTOR = "J28A" CONNECT TO
MAIN = TRUE TYPE = SOLENOID
 CHANNEL 2 NAME = "HSM 8" CONNECTOR = "J28B" CONNECT TO
MAIN = TRUE TYPE = SOLENOID

IO CARRIER
 ADDRESS=0xC2000000
 SLOT=3
 CLOCK MODE=BINARY
 SYSTEM RATE=1024
 MEDIUM SYSTEM RATE = 256.0
 LOW SYSTEM RATE = 25.6
 CLOCK TYPE = MASTER

 DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 1 NAME="493.25 DC-Slot 3-1" CONNECTOR="J4"
MODE=DC FILTER=300

 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 2 NAME="493.25 AC-Slot 3-2" CONNECTOR="J5"
MODE=AC FILTER=300

/* Daughter 3 is empty and used for optional boards */
```

```
DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT"
  CHANNEL 1 NAME="493.14 2SVD-Slot 3-4" CONNECTOR="J7"
RANGE=25 MODE=SINGLE CLAMP=DISABLED

IO CARRIER
 ADDRESS=0xC2200000
 SLOT=4
 CLOCK TYPE = SLAVE

 DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 1 NAME="493.25 DC-Slot 4-1" CONNECTOR="J4"
MODE=DC FILTER=300

 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 2 NAME="493.25 AC-Slot 4-2" CONNECTOR="J5"
MODE=AC FILTER=300

/* Daughter 3 is empty and used for optional boards */

 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.15
FILENAME="D3VD_53.OUT"
  CHANNEL 1 NAME="493.15 3SVD-Slot 4-3" CONNECTOR="J7"
CLAMP=DISABLED

IO CARRIER
 ADDRESS=0xC2400000
 SLOT=5
 CLOCK TYPE = SLAVE

 DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 1 NAME="493.25 DC-Slot 5-1" CONNECTOR="J4"
MODE=DC FILTER=300

 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 2 NAME="493.25 AC-Slot 5-2" CONNECTOR="J5"
MODE=AC FILTER=300

/* Daughter 3 is empty and used for optional boards */
```

```
 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT"
  CHANNEL 1 NAME="493.14 2SVD-Slot 5-4" CONNECTOR="J7"
RANGE=25 MODE=SINGLE CLAMP=DISABLED

IO CARRIER
 ADDRESS=0xC2600000
 SLOT=6
 CLOCK TYPE = SLAVE

DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 1 NAME="493.25 DC-Slot 6-1" CONNECTOR="J4"
MODE=DC FILTER=300

 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 2 NAME="493.25 AC-Slot 6-2" CONNECTOR="J5"
MODE=AC FILTER=300

/* Daughter 3 is empty and used for optional boards */

 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT"
  CHANNEL 1 NAME="493.14 2SVD-Slot 6-4" CONNECTOR="J7"
RANGE=25 MODE=SINGLE CLAMP=DISABLED

IO CARRIER
 ADDRESS=0xC2800000
 SLOT=7
 CLOCK TYPE = SLAVE

DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 1 NAME="493.25 DC-Slot 7-1" CONNECTOR="J4"
MODE=DC FILTER=300

 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 2 NAME="493.25 AC-Slot 7-2" CONNECTOR="J5"
MODE=AC FILTER=300

 /* Daughter 3 is empty and used for optional boards */
```

```
 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT"
  CHANNEL 1 NAME="493.14 2SVD-Slot 7-4" CONNECTOR="J7"
RANGE=25 MODE=SINGLE CLAMP=DISABLED

IO CARRIER
 ADDRESS=0xC2A00000
 SLOT=8
 CLOCK TYPE = SLAVE

DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 1 NAME="493.25 DC-Slot 8-1" CONNECTOR="J4"
MODE=DC FILTER=300

 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 2 NAME="493.25 AC-Slot 8-2" CONNECTOR="J5"
MODE=AC FILTER=300

 DAUGHTER 3 ADDRESS=0x20000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 3 NAME="493.25 AC-Slot 8-3" CONNECTOR="J6"
MODE=AC FILTER=300

 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT"
  CHANNEL 1 NAME="493.14 2SVD-Slot 8-4" CONNECTOR="J7"
RANGE=25 MODE=SINGLE CLAMP=DISABLED

IO CARRIER
 ADDRESS=0xC2C00000
 SLOT=9
 CLOCK TYPE = SLAVE

DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 1 NAME="493.25 DC-Slot 9-1" CONNECTOR="J4"
MODE=DC FILTER=300
```

```
 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.45
FILENAME="A2D_53.OUT"
   CHANNEL 2 NAME="Analog Input 1-Slot 9-2" CONNECTOR="J5"
   CHANNEL 3 NAME="Analog Input 2-Slot 9-2" CONNECTOR="J5"
   CHANNEL 4 NAME="Analog Input 3-Slot 9-2" CONNECTOR="J5"
   CHANNEL 5 NAME="Analog Input 4-Slot 9-2" CONNECTOR="J5"
   CHANNEL 6 NAME="Analog Input 5-Slot 9-2" CONNECTOR="J5"
   CHANNEL 7 NAME="Analog Input 6-Slot 9-2" CONNECTOR="J5"

 DAUGHTER 3 ADDRESS=0x20000 TYPE=#493.46
FILENAME="D2A_53.OUT"
   CHANNEL 1 NAME="Analog Output 1-Slot 9-3" CONNECTOR="J6"
   CHANNEL 2 NAME="Analog Output 2-Slot 9-3" CONNECTOR="J6"
   CHANNEL 3 NAME="Analog Output 3-Slot 9-3" CONNECTOR="J6"
   CHANNEL 4 NAME="Analog Output 4-Slot 9-3" CONNECTOR="J6"
   CHANNEL 5 NAME="Analog Output 5-Slot 9-3" CONNECTOR="J6"
   CHANNEL 6 NAME="Analog Output 6-Slot 9-3" CONNECTOR="J6"

 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT"
  CHANNEL 7 NAME="493.14 2SVD-Slot 9-4" CONNECTOR="J7"
RANGE=25 MODE=SINGLE CLAMP=DISABLED

IO CARRIER
 ADDRESS=0xC2E00000
 SLOT=10
 CLOCK TYPE = SLAVE

DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 1 NAME="493.25 DC-Slot 10-1" CONNECTOR="J4"
MODE=DC FILTER=300

 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.25
FILENAME="FRDUC_53.OUT"
  CHANNEL 2 NAME="493.25 AC-Slot 10-2" CONNECTOR="J5"
MODE=AC FILTER=300

 /* Daughter 3 is empty and used for optional boards */

 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT"
  CHANNEL 1 NAME="493.14 2SVD-Slot 10-4" CONNECTOR="J7"
RANGE=25 MODE=SINGLE CLAMP=DISABLED
```

```
DIO TRANSITION BOARD
 TRANSITION SLOT=10
 CONNECTOR = "J3"
  INPUT 1 NAME="Digital Input 1"
  INPUT 2 NAME="Digital Input 2"
  INPUT 3 NAME="Digital Input 3"
  INPUT 4 NAME="Digital Input 4"
  INPUT 5 NAME="Digital Input 5"
  INPUT 6 NAME="Digital Input 6"
  INPUT 7 NAME="Digital Input 7"
  INPUT 8 NAME="Digital Input 8"
  INPUT 9 NAME="Digital Input 9"
  INPUT 10 NAME="Digital Input 10"
  INPUT 11 NAME="Digital Input 11"
  INPUT 12 NAME="Digital Input 12"
  INPUT 13 NAME="Digital Input 13"
  INPUT 14 NAME="Digital Input 14"
  INPUT 15 NAME="Digital Input 15"
  INPUT 16 NAME="Digital Input 16"
 CONNECTOR="J4"
  OUTPUT 1 NAME="Digital Output 1"
  OUTPUT 2 NAME="Digital Output 2"
  OUTPUT 3 NAME="Digital Output 3"
  OUTPUT 4 NAME="Digital Output 4"
  OUTPUT 5 NAME="Digital Output 5"
  OUTPUT 6 NAME="Digital Output 6"
  OUTPUT 7 NAME="Digital Output 7"
  OUTPUT 8 NAME="Digital Output 8"
  OUTPUT 9 NAME="Digital Output 9"
  OUTPUT 10 NAME="Digital Output 10"
  OUTPUT 11 NAME="Digital Output 11"
  OUTPUT 12 NAME="Digital Output 12"
  OUTPUT 13 NAME="Digital Output 13"
  OUTPUT 14 NAME="Digital Output 14"
  OUTPUT 15 NAME="Digital Output 15"
  OUTPUT 16 NAME="Digital Output 16"
```

Appendix E
The .HWI File

TestStar™ IIm and FlexTest™ GT controllers use hardware interface (.hwi) files to determine what electronic components are available to your system, where they are located, and which connectors are associated with them. The electronic components defined in the .hwi file include:

- processor modules
- hydraulic control resources
- valve drivers, conditioners
- analog inputs and outputs
- digital inputs and outputs
- temperature controllers
- remote station controllers
- global interlock resources
- encoder resources

Your test system comes equipped with one of the following hardware interface files, depending on your system controller:

- **tsiismc.hwi** file (This file represents the actual components installed in your TestStar™ IIm test controller.)
- **ftgt.hwi** file (This file represents the actual components installed in your FlexTest™ GT test controller.)

If a module is added, removed, or repositioned in your chassis, you must revise your .hwi file to reflect the new configuration. You can edit the hardware interface file with a text editor.

CAUTION

Do not edit your .hwi file unless you know what you are doing.

Your system software will not function if the required file structure is not followed. Be sure to create a back up copy of your .hwi file before revising it.

The file format of the *.hwi file is critical. An errant or misplaced space, comma, period, or character can make the file nonfunctional. A misspelling can also cause the file to be nonfunctional.

Adding optional hardware

Definitions for optional supported hardware are included at the end of your .hwi file. When any of these components are added to your system you must:

1. Remove the comment markers(/* **definition** */) from either side of the component definition.
2. Edit the definition for required board ID, slot information, channel number, and other necessary information (e.g., baud rate, master clock definition)
3. Move the edited definition to the appropriate section of the file.

This appendix describes how each component definition must be formatted. This information is provided so you can edit the **tsiismc.hwi** file for your system. See "A Sample File" on page 310 for an example of an .hwi file for a typical system.

Processor

This block defines the processor modules installed in the 493.10 Chassis. The information shown is the same for all systems using the 498.93-1 and 498.93-2 Processor modules. Do not change the information in this block.

PC Interface Processor Functions

```
PROCESSOR
 ADDRESS=0xC8000000
 SLOT=1
 FUNCTION=SUPERVISOR
 PROCESSOR NUMBER=0
 INTERRUPT LEVEL=2
 FILENAME="tsiismcsup.o"
 PORT=ETHERNET
 IP
ADDRESS="148.150.203.1913333"

PROCESSOR
 ADDRESS=0x00000
 SLOT=1
FUNCTION=CONTROL
 PROCESSOR NUMBER=1
 INTERRUPT LEVEL=5
 FILENAME="tsiismcdsp.o"
 SHARED MEMORY=0x700000
```

Do not change the information in this block.

Hydraulic Control

The hydraulic control definition assigns the Hydraulic Power Unit (HPU) transition board and each Hydraulic Service Manifold (HSM) transition board to their appropriate rear panel connectors. Each of the two HSM transition boards allowed in your system can support up to two HSM stations.

Setting FIRST ON and LAST OFF to FALSE allows HPU turn on, independent of HSM power.

Setting FIRST ON and LAST OFF to TRUE allows HSM Low selection to activate HPU High without pressing the HPU buttons.

Changing VISIBLE to FALSE turns off the HPU button display on the Station Manager window.

The HSM type can be PROPORTIONAL, SOLENOID, or ON_OFF_SOLENOID.

Only the PROPORTIONAL type requires the second line. It defines the characteristics of the proportional output. See "J28 HSM" on page 61.

For systems without an HSM, change MAIN POWER to FALSE to allow HPU 1 to be a power selection option in Station Builder.

```
HPU TRANSITION BOARD
 TRANSITION SLOT = 9
 NAME = "HPU"
 MAIN POWER = TRUE

FIRST ON = TRUE
 LAST OFF = TRUE

VISIBLE = TRUE

CONNECTOR = "J25"

HSM TRANSITION BOARD
 TRANSITION SLOT = 8
 CHANNEL 1 NAME = "HSM 1" CONNECTOR = "J28A" CONNECT
TO MAIN = TRUE TYPE = PROPORTIONAL
HSM RATE = SLOW    HSM OFF  MODE = STEP   LOW
PERCENT=50  HIGH PERCENT=100

CHANNEL 2 NAME = "HSM 2" CONNECTOR = "J28B" CONNECT
TO MAIN = TRUE TYPE = SOLENOID
/*
 HSM RATE = SLOW    HSM OFF  MODE = STEP   LOW PERCENT=50
HIGH PERCENT=100
*/
```

The SOLENOID and ON_OFF_SOLENOID types do not need an entry to define their characteristics. The proportional characteristics should be commented out or deleted.

I/O Carrier

The I/O Carrier definition describes each Model 493.40 I/O Carrier module installed in the 493.10 Chassis and their installed daughter boards. Up to 8 I/O Carrier modules can be installed in your system. Each I/O Carrier module can support up to 4 daughter boards.

The I/O Carrier module in slot three provides the master clock (**CLOCK TYPE=MASTER**) for all other Carrier I/O modules. If a GRES III module is added (always to Slot 10), the clock type for this I/O Carrier module must be changed to **CLOCK TYPE= SLAVE**.

Adding I/O Carrier Modules

Each Model 493.40 I/O Carrier module added to the 493.10 Chassis must be described in the I/O Carrier definition. A typical description for an added I/O Carrier module is shown below:

```
IO CARRIER
 ADDRESS=0xC2200000
 SLOT=4
 CLOCK TYPE = SLAVE
```

You must set the address on the added I/O Carrier module to match the address specified in the I/O Carrier module's definition. See "Setting I/O Carrier addresses" on page 32.

I/O Carrier Addresses

As additional I/O Carrier modules are installed their addresses increment as follows:

I/O Carrier Module	Address
First	0xC**20**00000
Second	0xC**22**00000
Third	0xC**24**00000
Fourth	0xC**26**00000
Fifth	0xC**28**00000
Sixth	0xC**2A**00000
Seventh	0xC**2C**00000
Eighth	0xC**2E**00000

```
IO CARRIER
 ADDRESS=0xC2000000
 SLOT=3
 CLOCK MODE=BINARY
 HI RATE = 4096
 SYSTEM RATE=4096
 MEDIUM SYSTEM RATE = 256.0
 LOW SYSTEM RATE = 25.6
 CLOCK TYPE = MASTER /* " When adding a GRESIII, CLOCK TYPE =
SLAVE " */

 DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.21B
FILENAME="DUCB_53.OUT"
  CHANNEL 1 NAME="493.21B DC-Slot 3-1" CONNECTOR="J4" MODE=DC
FILTER=1000

 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.21B
FILENAME="DUCB_53.OUT"
  CHANNEL 2 NAME="493.21B AC-Slot 3-2" CONNECTOR="J5" MODE=AC
FILTER=1000

/* Daughter 3 is empty and used for optional boards */

 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT"
  CHANNEL 1 NAME="493.14 2SVD-Slot 3-4" CONNECTOR="J7"
RANGE=25 MODE=SINGLE CLAMP=DISABLED

IO CARRIER
 ADDRESS=0xC2200000
 SLOT=4
 CLOCK TYPE = SLAVE

 DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.21B
FILENAME="DUCB_53.OUT"
  CHANNEL 1 NAME="493.21B DC-Slot 4-1" CONNECTOR="J4"
MODE=DC FILTER=1000

DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.21B
FILENAME="DUCB_53.OUT"
  CHANNEL 2 NAME="493.21B AC-Slot 4-2" CONNECTOR="J5" MODE=AC
FILTER=1000
```

Each added I/O Carrier Module requires the entry of a four line description

Clock Type

Each added I/O Carrier module receives master clock signals from the first I/O Carrier module in slot 3 (or a GRES III module if installed) and has the defined clock type: CLOCK TYPE = SLAVE.

I/O Carrier daughter boards

The I/O Carrier daughter boards plug into the Model 493.40 I/O Carrier module. Each daughter board described below can be assigned to one of the I/O Carrier module rear panel connectors (**J4-J7 I/O**).

Transducer connections require a conditioner daughter board be installed in the I/O Carrier module. The following conditioners can be installed:

- Model 493.21B Digital Universal Conditioner
- Model 493.25 Digital Universal Conditioner
- Model 493.47 Encoder
- Model 493.48 Acceleration Conditioner

- Valve connections require a valve driver daughter board be installed in the I/O Carrier module. The following valve drivers can be installed:
  - Model 493.14 Valve Driver
  - Model 493.15 3-Stage Valve Driver
- Analog I/O connections require an A/D or D/A daughter board be installed in the I/O Carrier module. The following analog daughter boards can be installed:
  - Model 493.45 A/D Converter
  - Model 493.46 D/A Converter

Daughter board ID

Each type of daughter board has an identification code labeled as TYPE=, FILENAME=. For example:

- The digital universal conditioner (DUC) daughter board is identified as: TYPE=#493.21B FILENAME="DUCB_53.OUT"
- The encoder daughter board is identified as: TYPE=#493.47 FILENAME="ENC_53.OUT"
- The acceleration conditioner daughter board is identified as: TYPE=#493.48 FILENAME="NONE"
- A two-stage valve driver daughter board may be identified as: TYPE=#493.14 FILENAME="D2VD_53.OUT".
- A three-stage valve driver daughter board may be identified as: TYPE=#493.15 FILENAME="D3VD_53.OUT".

- The D/A output daughter board is identified as: TYPE=#493.46 FILENAME="D2A_53.OUT".
- The A/D input daughter board is identified as: TYPE=#493.45 FILENAME="A2D_53.OUT".

Connector assignment

Each daughter board definition requires a board address. The address specifies a Carrier I/O module front panel connector (**J4-J7**). In the following example, a 493.21 Universal Conditioner is assigned a board address (**ADDRESS=0x00000**) which specifies the front panel connector J4 (**CONNECTOR=J4**).

```
DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.21B
FILENAME="DUCB_53.OUT"
CHANNEL 1 NAME="493.21B DC-Slot 3-1" CONNECTOR="J4"
MODE=DC FILTER=1000
```

Channel numbering

Channel numbers must be defined in terms of all analog outputs and all analog inputs in each I/O Carrier. Channel numbers can't be shared with other resources of the same type. The .hwi file has analog output channels 1–X and analog input channels 1–X.

Note *Channel numbering is unique to each I/O Carrier module. Resources of the same type on different I/O Carrier modules can have the same channel numbers.*

For example, the analog outputs and the valve driver daughter board define analog outputs. If the analog output channels define output channels 1 through 6, then the valve driver must be assigned channel 7. An additional D/A board would define channels 8,9,10 and so on.

```
 DAUGHTER 3 ADDRESS=0x20000 TYPE=#493.46
FILENAME="D2A_53.OUT" /* outputs */
   CHANNEL 1 NAME="Analog Output 1 I/O-1" CONNECTOR="J6"
   CHANNEL 2 NAME="Analog Output 2 I/O-1" CONNECTOR="J6"
   CHANNEL 3 NAME="Analog Output 3 I/O-1" CONNECTOR="J6"
   CHANNEL 4 NAME="Analog Output 4 I/O-1" CONNECTOR="J6"
   CHANNEL 5 NAME="Analog Output 5 I/O-1" CONNECTOR="J6"
   CHANNEL 6 NAME="Analog Output 6 I/O-1" CONNECTOR="J6"

 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT" /* outputs */
  CHANNEL 7 NAME="493.14 2SVD-1 I/O-1" CONNECTOR="J7"
RANGE=25 MODE=SINGLE
```

The same is true for analog inputs. For example, the A/D daughter board and the conditioner daughter boards are analog inputs. If the conditioner daughter boards define input channels 1–2, the A/D daughter board must be defined as channels 3-8 and so on.

DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.21B FILENAME="DUCB_53.OUT"
CHANNEL 1 NAME="493.21B DC-Slot 3-1" CONNECTOR="J4" MODE=DC FILTER=1000

DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.21B FILENAME="DUCB_53.OUT"
CHANNEL 2 NAME="493.21B AC-Slot 3-2" CONNECTOR="J5" MODE=AC FILTER=1000

DAUGHTER 3 ADDRESS=0x20000 TYPE=#493.45 FILENAME="A2D_53.OUT"

CHANNEL 3 NAME="Analog Input 1-Slot Y-3" CONNECTOR="J6"

CHANNEL 4 NAME="Analog Input 2-Slot Y-3" CONNECTOR="J6"

CHANNEL 5 NAME="Analog Input 3-Slot Y-3" CONNECTOR="J6"

CHANNEL 6 NAME="Analog Input 4-Slot Y-3" CONNECTOR="J6"

CHANNEL 7 NAME="Analog Input 5-Slot Y-3" CONNECTOR="J6"

CHANNEL 8 NAME="Analog Input 6-Slot Y-3" CONNECTOR="J6"

ADDA II module

When the optional Model 493.50 ADDA II module is being used, the .hwi file describes this module and the A/D, D/A, and encoder daughter boards that are installed on it.

Adding ADDA II modules

Each Model 493.50 ADDA II module added to the 493.10 Chassis must be described in the ADDA II definition. A typical description for an added ADDA II module is shown below:

```
ADDAII
 ADDRESS=0x0
 SLOT=7
 CLOCK TYPE = SLAVE
```

You must set the address on the added ADDA II module to match the address specified in the ADDA II module's definition. See "Setting ADDA II addresses" on page 33 for more detailed information.

ADDA II addresses

As additional ADDA II modules are installed their addresses increment as follows:

ADDA II Module	Address (set on ADDA II board)	Address (.hwi)
First	0xC**40**00000	0x0
Second	0xC**41**00000	0x1
Third	0xC**42**00000	0x2
Fourth	0xC**43**00000	0x3
Fifth	0xC**44**00000	0x4

ADDA II daughter boards

The following ADDA II daughter boards can be installed:

- Model 493.55 A/D (8-Channel)
- Model 493.56 D/A (8-Channel)
- Model 493.57 DSPAD (8-Channel)
- Model 493.59 Universal Encoder (1-Channel)

Each daughter board can be assigned to one of the four ADDII module rear panel connectors.

Daughter board ID

- Each A/D or D/A daughter board definition is followed by eight signal definitions.
- A second daughter board of the same type (A/D or D/A) continues the channel count sequence. For example, a second A/D daughter board begins at channel 9.

```
ADDAII
 ADDRESS=0x0
 SLOT=7
CLOCK TYPE = SLAVE
 DAUGHTER 1 ADDRESS= 0x1 TYPE=#493.55 FILTER=OFF

DAUGHTER 4 ADDRESS= 0x4 TYPE=#493.56 FILTER=OFF
```

This block defines an ADDA II module.

This specifies an A/D daughter board.

This block defines an ADDA II daughter board.

These define an ADDA II daughter board location.

This specifies a D/A daughter board.

The analog I/O definitions provide A/D channels and D/A channels for analog inputs and outputs from the 498 Analog In transition boards.

Input and output channels

- The channel numbers for the analog inputs represent the available analog-to-digital converters following the list of AC and DC conditioner signals.
- The channel numbers for the analog outputs represent the available digital-to-analog converters following the list of valve command signals.

```
CHANNEL 13 NAME="Analog Input 1" CONNECTOR="J14"
```

This block defines an analog input signal. It will always be listed as a channel in an A/D daughter board.

The name in quotes (“ ”) appears in the Station Builder application as a system resource.

This connector is located on the ADDA II front panel.

```
CHANNEL 5 NAME="Analog Output 1" CONNECTOR="J18"
```

This block defines an analog output signal. It will always be listed as a channel in a D/A daughter board.

DSPAD

The Model 493.57 DSPAD daughter card, available for installation on ADDA II modules, provides 8 channels of A/D with digital filtering. A DSPAD .hwi definition is shown below.

Note that for DSPAD cards the FILTER should be set to ON

Filter cut-off frequency

```
DAUGHTER 2 ADDRESS= 0x2 TYPE=#493.57 FILTER=ON
 CHANNEL 9  NAME="Analog Input 56k 1" CONNECTOR="J13" FILTER=ELLIP4_500
 CHANNEL 10 NAME="Analog Input 56k 2" CONNECTOR="J13" FILTER=ELLIP4_1000
 CHANNEL 11 NAME="Analog Input 56k 3" CONNECTOR="J13" FILTER=ELLIP4_1500
 CHANNEL 12 NAME="Analog Input 56k 4" CONNECTOR="J13" FILTER=ELLIP4_2000
 CHANNEL 13 NAME="Analog Input 56k 5" CONNECTOR="J14" FILTER=OFF
 CHANNEL 14 NAME="Analog Input 56k 6" CONNECTOR="J14" FILTER=OFF
 CHANNEL 15 NAME="Analog Input 56k 7" CONNECTOR="J14" FILTER=OFF
 CHANNEL 16 NAME="Analog Input 56k 8" CONNECTOR="J14" FILTER=OFF
```

Encoders

Encoders require a special daughter board be plugged into the ADDA II module. The encoder daughter board can occupy any of the four ADDA II address locations.

- The encoder daughter board supports four encoder signals.
- The encoder daughter board processes the pulse stream from an encoder.

Encoder daughter boards use the following designators for each type of encoder: **1** for absolute encoders, **3** for incremental encoders, and **5** for Temposonics III encoders.

The designation -3 specifies a daughter board for incremental encoders.

```
DAUGHTER 3 ADDRESS= 0x3 TYPE=#493.59-3
 CHANNEL 13 NAME="Encoder Input 1" CONNECTOR="J15"
 CHANNEL 14 NAME="Encoder Input 2" CONNECTOR="J15"
 CHANNEL 15 NAME="Encoder Input 3" CONNECTOR="J16"
 CHANNEL 16 NAME="Encoder Input 4" CONNECTOR="J16"
```

Temposonics III

Temposonics III sensors require a special daughter board on the ADDA module. The Temposonics III daughter board can occupy any of the four ADDA address locations.

- The Temposonics III daughter board supports two "double-wide" Temposonics sensor signals.
- The Temposonics III daughter board processes pulses from the digital output of a Temposonics III sensor.
- The Analog I/O signal definitions on page 301 and page 302 also apply to the Temposonics III definition..

The designation -5 specifies a daughter board for Temposonics III sensors.

```
DAUGHTER 2 ADDRESS= 0x2 TYPE=#493.59-5
 CHANNEL 9  NAME="TemposonicsIII Input 1" CONNECTOR="J13"
 CHANNEL 10 NAME="TemposonicsIII Input 2" CONNECTOR="J14"
```

Digital I/O

The DIO Transition Board definition describes the Model 493.72 Digital I/O Transition Panel digital input and outputs. The information shown defines 16 digital inputs and 16 digital outputs.

```
DIO TRANSITION BOARD
 TRANSITION SLOT=4
 CONNECTOR = "J3"
  INPUT 1 NAME="Digital Input 1"
  INPUT 2 NAME="Digital Input 2"
  INPUT 3 NAME="Digital Input 3"
  INPUT 4 NAME="Digital Input 4"
  INPUT 5 NAME="Digital Input 5"
  INPUT 6 NAME="Digital Input 6"
  INPUT 7 NAME="Digital Input 7"
  INPUT 8 NAME="Digital Input 8"
  INPUT 9 NAME="Digital Input 9"
  INPUT 10 NAME="Digital Input 10"
  INPUT 11 NAME="Digital Input 11"
  INPUT 12 NAME="Digital Input 12"
  INPUT 13 NAME="Digital Input 13"
  INPUT 14 NAME="Digital Input 14"
  INPUT 15 NAME="Digital Input 15"
  INPUT 16 NAME="Digital Input 16"
 CONNECTOR="J4"
  OUTPUT 1 NAME="Digital Output 1"
  OUTPUT 2 NAME="Digital Output 2"
  OUTPUT 3 NAME="Digital Output 3"
  OUTPUT 4 NAME="Digital Output 4"
  OUTPUT 5 NAME="Digital Output 5"
  OUTPUT 6 NAME="Digital Output 6"
  OUTPUT 7 NAME="Digital Output 7"
  OUTPUT 8 NAME="Digital Output 8"
  OUTPUT 9 NAME="Digital Output 9"
  OUTPUT 10 NAME="Digital Output 10"
  OUTPUT 11 NAME="Digital Output 11"
  OUTPUT 12 NAME="Digital Output 12"
  OUTPUT 13 NAME="Digital Output 13"
  OUTPUT 14 NAME="Digital Output 14"
  OUTPUT 15 NAME="Digital Output 15"
  OUTPUT 16 NAME="Digital Output 16"
```

The name in quotes (“ “) appears in Station Builder as a system resource. You can edit this name.

Valve Signals

The valve driver definition describes the valve driver daughter board. Your .hwi file supports two- and three-stage valve drivers.

- The preferred (and recommended) module location is ADDRESS= 0x30000 and CONNECTOR= J7.
- To prevent unwanted actuator movement when a hydraulic interlock occurs, the valve will be clamped as specified with the **Clamp =** definition in the .hwi file as follows:
  - **DISABLED**–Valve does not clamp. This is the default action if the clamp entry is omitted.
  - **ZERO**–Clamps the servovalve to zero—if valve balance is used, it will clamp to this value.
  - **POSITIVE**–Clamps the servovalve to positive 50% spool opening on a 2-stage valve driver, 50% outer-loop command on the 3-stage valve driver.
  - **NEGATIVE**–Clamps the servovalve to negative 50% spool opening on a 2-stage valve driver, 50% outer-loop command on a 3-stage valve driver.

Two-stage valve driver

The address specifies the front panel connector.

The TYPE= and FILENAME= identify the daughter board as a valve driver.

The MODE= identifies single or multiple valve driver support. The settings are SINGLE or DUAL. Dual valve driver support requires a special manifold.

```
DAUGHTER 1 ADDRESS= 0x30000   TYPE=#493.14 FILENAME="DVD_53.OUT"
CHANNEL 3 NAME="493.14 2SVD-Slot 1"   CONNECTOR="J7"   RANGE=25    MODE=SINGLE
CLAMP=DISABLED
```

(See "Valve Signals" on page 298 for descriptions of **Clamp=** definitions

The name in quotes (" ") appears in the Station Builder application as a system resource. You can edit this if you want.

The board address determines the connector that must be specified here. .

The RANGE= identifies the output (in mA) of the valve driver itself. The settings are 25 or 50.

Three-stage valve driver

```
DAUGHTER 1 ADDRESS= 0x300000 TYPE=#493.15 FILENAME="D3VD_53.OUT"
CHANNEL 3 NAME="493.15 3SVD-Slot 1" CONNECTOR="J1" CLAMP=DISABLED
```

Multiple Universal Driver

For special applications, the Model 493.79 Multiple Universal Driver (MUD) board can provide up to six driver signals to drive standard 252 servovalves.

Inputs to the MUD board originate from a Model 493.46 D/A daughter board on the a Model 493.40 Carrier modules. See “ADDA II Connections” on page 61.

A typical .hwi file definition for a D/A board-MUD board combination is shown here.

The address specifies the front panel connector.

CONNECTOR= identifies the I/O Carrier rear panel connector that is available for MUD board output.

```
DAUGHTER 3 ADDRESS=0x20000 TYPE=#493.46 FILENAME="D2A_53.OUT"
  CHANNEL 1 NAME="493.79 MUD, T5-1" CONNECTOR="J6"
   DRIVER TYPE=#493.79 SLOT=5 CHANNEL=1 RANGE=25 INTERLOCK=1
  CHANNEL 2 NAME="493.79 MUD, T5-2" CONNECTOR="J6"
   DRIVER TYPE=#493.79 SLOT=5 CHANNEL=2 RANGE=50 INTERLOCK=1
  CHANNEL 3 NAME="493.79 MUD, T5-3" CONNECTOR="J6"
   DRIVER TYPE=#493.79 SLOT=5 CHANNEL=3 RANGE=75 INTERLOCK=1
  CHANNEL 4 NAME="493.79 MUD, T5-4" CONNECTOR="J6"
   DRIVER TYPE=#493.79 SLOT=5 CHANNEL=4 RANGE=0 INTERLOCK=1
  CHANNEL 5 NAME="493.79 MUD, T5-5" CONNECTOR="J6"
   DRIVER TYPE=#493.79 SLOT=5 CHANNEL=5 RANGE=25 INTERLOCK=1
  CHANNEL 6 NAME="493.79 MUD, T5-6" CONNECTOR="J6"
   DRIVER TYPE=#493.79 SLOT=5 CHANNEL=6 RANGE=25 INTERLOCK=1
```

The name in quotes (“ ”) appears in the Station Builder application as a system resource. You can edit this if you want.

RANGE= identifies the output (in mA) of the valve driver itself. The settings are 0, 25, 50, or 75. The 0 setting requires an on-board user-selectable resistor.

INTERLOCK= indicates the status of cable loss detection: 0 disables, 1 enables

Analog Output

The analog output definition describes the D/A Analog Output daughter board.

- The CONNECTOR= specification identifies the rear panel connector that is available for analog outputs.

The address specifies the front panel connector.

The TYPE= and FILENAME= identify the daughter board as a D/A board.

```
DAUGHTER 2 ADDRESS= 0x10000    TYPE=#493.46  FILENAME="D2A_53.OUT"
 CHANNEL 4 NAME="Analog Output 1-Slot 2" CONNECTOR="J5"
 CHANNEL 5 NAME="Analog Output 2-Slot 2" CONNECTOR="J5"
 CHANNEL 6 NAME="Analog Output 3-Slot 2" CONNECTOR="J5"
 CHANNEL 7 NAME="Analog Output 4-Slot 2" CONNECTOR="J5"
 CHANNEL 8 NAME="Analog Output 5-Slot 2" CONNECTOR="J5"
 CHANNEL 9 NAME="Analog Output 6-Slot 2"   CONNECTOR="J5"
```

The name in quotes (“ ”) appears in the Station Builder application as a system resource. You can edit this if you want.

The board address determines the connector that must be specified here.

Analog Input

The analog input definition describes the A/D Analog Input daughter board.

- The CONNECTOR= specification identifies the rear panel connector that is available for analog inputs.

The address specifies the front panel connector.

The TYPE= and FILENAME= identify the daughter board as an A/D board.

```
DAUGHTER 3 ADDRESS= 0x20000   TYPE=#493.45   FILENAME="A2D_53.OUT"
 CHANNEL 1 NAME="Analog Input 1-Slot 3" CONNECTOR="J6"
 CHANNEL 2 NAME="Analog Input 2-Slot 3" CONNECTOR="J6"
 CHANNEL 3 NAME="Analog Input 3-Slot 3" CONNECTOR="J6"
 CHANNEL 4 NAME="Analog Input 4-Slot 3" CONNECTOR="J6"
 CHANNEL 5 NAME="Analog Input 5-Slot 3" CONNECTOR="J6"
 CHANNEL 6 NAME="Analog Input 6-Slot 3"   CONNECTOR="J6"
```

The name in quotes (“ ”) appears in the Station Builder application as a system resource. You can edit this if you want.

The board address determines the connector that must be specified here.

Conditioner Signals

The conditioner definitions describe the characteristics of the Digital Universal Conditioner (DUC) daughter board.

- Each DUC daughter board specifies the type of conditioning the DUC will perform. AC or DC are the only choices for the MODE= specification.
- The FILTER= specification can be set to 0 (no filter), 50 (Hz), 100 (Hz), 300 (Hz), 500 (Hz), or 1000 (Hz).

The address specifies the front panel connector.

The TYPE= and FILENAME= identify the daughter board as a conditioner.

```
DAUGHTER 1 ADDRESS= 0x00000  TYPE=#493.21B  FILENAME="DUCB_53.OUT"
 CHANNEL 1 NAME="493.21B DC-Slot 4" CONNECTOR="J4" MODE=DC FILTER=1000

DAUGHTER 2 ADDRESS= 0x10000 TYPE=#493.21 FILENAME="DUC_53.OUT"
 CHANNEL 2 NAME="493.21 DC-Slot 5" CONNECTOR="J5" MODE=DC FILTER=1000

DAUGHTER 3 ADDRESS= 0x20000 TYPE=#493.21 FILENAME="DUC_53.OUT"
 CHANNEL 3 NAME="493.21 AC-Slot 6"  CONNECTOR="J6"  MODE=AC  FILTER=1000
```

The name in quotes (“ ”) appears in the Station Builder application as a system resource. You can edit this if you want.

The board address determines the connector that must be specified here.

This specifies if the conditioner operates as an AC or DC conditioner.

Acceleration conditioner signals

On systems affected by acceleration induced errors, an optional acceleration conditioner board can be linked to a DC conditioner (DUCB only) to perform load washing.

- The acceleration conditioner definition specifies a list of auxiliary inputs that the DUC conditioners can use on the acceleration daughter board. (Each DUC daughter board definition is enhanced to allow an auxiliary input to be defined.)
- The load washer configuration will be identified by additional text following the desired DUC definition. The first entry is "RANGES". It must be placed after the FILTER definition or after the MODE definition if no filter selection is specified. (It can also be placed after the AUXILIARY INPUT definition if acceleration conditioning is used.)
- Following the RANGES entry, the digital outputs to be controlled are listed. They will be strings prefaced with RANGE=rangeName. The rangeName can be any string, but must match the range name given to the range in the sensor file.

Defines the acceleration conditioner daughter board

Defines the auxiliary input each DUC will use on the accel daughter board.

Defines the resources needed for load washing.

```
 DAUGHTER 2 ADDRESS= 0x00000 TYPE=#493.48 FILENAME="NONE"
  CHANNEL 1 NAME="493.48  Accel 1"  CONNECTOR="J3"
  CHANNEL 2 NAME="493.48  Accel 2"  CONNECTOR="J3"
  CHANNEL 3 NAME="493.48  Accel 3"  CONNECTOR="J3"

 DAUGHTER 1 ADDRESS= 0x00000 TYPE=#493.21B FILENAME="DUCB_53.OUT"
  CHANNEL 1 NAME="493.21B DC-Slot 3" CONNECTOR="J4" MODE=DC
FILTER=1000
   AUXILIARY INPUT = "493.48  Accel 1"

 DAUGHTER 2 ADDRESS= 0x10000 TYPE=#493.21B FILENAME="DUCB_53.OUT"
  CHANNEL 2 NAME="493.21B DC-Slot 4" CONNECTOR="J5" MODE=DC
FILTER=1000
   AUXILIARY INPUT = "493.48  Accel 2"

 DAUGHTER 3 ADDRESS= 0x20000 TYPE=#493.21B FILENAME="DUCB_53.OUT"
  CHANNEL 3 NAME="493.21B DC-Slot 5" CONNECTOR="J6" MODE=DC
FILTER=1000
   AUXILIARY INPUT = "493.48  Accel 3"

 DAUGHTER 4 ADDRESS= 0x30000 TYPE=#493.21B FILENAME="DUCB_53.OUT"
  CHANNEL 4 NAME="493.21B AC-Slot 6" CONNECTOR="J7" MODE=AC
FILTER=1000

 RANGES
    RANGE="Range 1" RANGE="Range 2" RANGE="Range 3"
RANGE="Range 4"

    ENABLE="Digital Output 1" ZEROBIT="Digital Output 2" ONEBIT="Digital Output
3"
```

Encoder/temposonics sensor support

The encoder definition describes the optional 493.47 Digital Encoder daughter board. This board must be installed if you want to monitor encoder or Temposonics sensor feedback.

```
DAUGHTER 3 ADDRESS= 0x20000 TYPE=#493.47 FILENAME="ENC_53.OUT"

CHANNEL 3 NAME="493.47  Encoder-Slot 2" CONNECTOR="J6"   MODE=Incremental
```

The channel name appears in the Station Builder application as a system resource with "input" and "output" appended to it. These special analog inputs/outputs are handled differently than other analog channels.

MODE= specifies what type of device is to be connected. Options are INCREMENTAL, TEMPO24BIT, TEMPO25BIT, and TELEDYNE.

Temperature controller

This indicates a Eurotherm 2200 or 2400 series temperature controller is connected to the controller. A GRESIII module is needed to support either a temperature controller or RSC. For information on adding a GRES III module, see “GRES III” on page 309.

Due to hardware limitations, if an RSC is used on COM1 and a temperature controller is on COM2 (or vice versa), the temp controller baud rate must be 9600. The same goes for COM3 & COM4.

```
TEMP CONTROL
 TYPE="Eurotherm 2208"
 HOST PORT="GRES COM 2"
 BAUD=9600
 CHANNEL 1 NAME="Temp Control 1"   ADDRESS=0x1
```

These entries must match the configuration of the temperature controller

The channel name appears in the Station Builder application as a system resource with "input" and "output" appended to it. These special analog inputs/outputs are handled differently than other analog channels.

Remote station controller

The Remote Station Controller (RSC) module is a table-top, stand-mounted, or hand-held module that is primarily used for specimen installation and the starting and stopping of tests. The RSC definition is always the same. A GRES III module is needed to support an RSC in your system. For information on adding a GRES III module, see "GRES III" on page 309.

HWI file additions

In order to use one or more RSCs with your Model 493.10 Chassis, two sections must be added to your .hwi file, an RSC section and a GRES III section.

Note *Remote Station Controllers are not available with the optional 6 or 8-station system configurations*

Note *If you specified RSC support when you ordered your test system, RSC and GRES III sections will be added to your .hwi file at the factory.*

RSC section

The RSC section of the .hwi file defines a number of RSC parameters including:

- NAME—The name entry names the RSC resource (it is arbitrary).
- HOST PORT—The host port entry specifies which Com port on the GRES III plug-in module the Model 493.71 Serial Interface transition module port is mapped to. (This determines which port the RSC must be plugged into.)
- FILENAME—The filename entry specifies the name of the file in the NTBIN folder that contains the firmware for the RSCs (pod.hex is the default file).

A configuration file that defines an RSC contains the following entries:

```
RSC
 NAME="RSC 1" HOST PORT="GRES COM 1" FILENAME="POD.HEX"
```

Note *If you do not have an RSC, this line must be commented out and a jumper plug installed in J50.*

For additional information on editing your .hwi file to accommodate RSCs, contact MTS.

GRES III

The Model 498.71 GRES III module supports both the Remote Station Controller (RSC) and the Temperature Controller and must be added to your system when using either of these components. To add a GRES III module to your system:

1. Install the GRES III module in slot 10 of the chassis front panel.
2. In your system .hwi file, remove the comment markers (/* **definition***/) from either side of the GRES III module definition shown below.

```
/*GRESIII
 ADDRESS=0xC0800000
 SLOT=10
 SERIAL TRANSITION BOARD
   TRANSITION SLOT = 10
   STARTING INTERLOCK = 1
 SERIAL PORT 1
  NAME="GRES COM 1"
 SERIAL PORT 2
  NAME="GRES COM 2"
 SERIAL PORT 3
  NAME="GRES COM 3"
 SERIAL PORT 4
  NAME="GRES COM 4"
 SERCLK RATE = 4915200
 HI RATE = 4096.0
 LO RATE = 25.6
 SYSTEM RATE=4096
 CLOCK TYPE = MASTER
*/
```

3. Move to an appropriate section of the .hwi file.
4. In the .hwi file definition for the Model 493.40 I/O Carrier module providing the master clock signal (typically found in slot 3), change **CLOCK TYPE = MASTER** to **CLOCK TYPE = SLAVE**.

A Sample File

This is an tsiismc.hwi file that defines resources for a multi-channel TestStar IIm system. This system includes standard and optional hardware, including:

- Four 2-stage valve drivers
- One 3-stage valve driver
- One encoder
- One A/D daughter board
- One D/A daughter board
- Eight conditioners (four DC, four AC)
- GRES III module
- A temperature controller
- Four remote station controllers

The file listing

The following is an actual ftiim.hwi file:

```
/* Both processor entries are needed for single processor systems. */

PROCESSOR
 ADDRESS=0xC8000000
 SLOT=1
 FUNCTION=SUPERVISOR
 PROCESSOR NUMBER=0
 INTERRUPT LEVEL=2
 FILENAME="tsiismcsup.o"
 PORT=ETHERNET
 IP ADDRESS="148.150.203.191"

PROCESSOR
ADDRESS=0x00000
 SLOT=1
 FUNCTION=CONTROL
 PROCESSOR NUMBER=1
 INTERRUPT LEVEL=5
 FILENAME="tsiismcdsp.o"
 SHARED MEMORY=0x700000
```

```
HPU TRANSITION BOARD
 TRANSITION SLOT = 9
 NAME = "HPU"
 MAIN POWER = TRUE
 FIRST ON = TRUE
 LAST OFF = TRUE
 VISIBLE = TRUE
 CONNECTOR = "J25"


SYSTEM OPTIONS

  /*VELOCITY LIMITER*/

HSM TRANSITION BOARD
 TRANSITION SLOT = 8
 CHANNEL 1 NAME = "HSM 1" CONNECTOR = "J28A" CONNECT TO
MAIN = TRUE TYPE = PROPORTIONAL
  HSM RATE = SLOW LOW PERCENT=50 HIGH PERCENT=100
 CHANNEL 2 NAME = "HSM 2" CONNECTOR = "J28B" CONNECT TO
MAIN = TRUE TYPE = PROPORTIONAL
  HSM RATE = SLOW LOW PERCENT=50 HIGH PERCENT=100


HSM TRANSITION BOARD
 TRANSITION SLOT = 6
 CHANNEL 1 NAME = "HSM 3" CONNECTOR = "J28A" CONNECT TO
MAIN = TRUE TYPE = PROPORTIONAL
  HSM RATE = SLOW LOW PERCENT=50 HIGH PERCENT=100
 CHANNEL 2 NAME = "HSM 4" CONNECTOR = "J28B" CONNECT TO
MAIN = TRUE TYPE = PROPORTIONAL
  HSM RATE = SLOW LOW PERCENT=50 HIGH PERCENT=100


GRESIII
 ADDRESS=0xC0800000
 SLOT=10
 SERIAL TRANSITION BOARD
   TRANSITION SLOT = 10
   STARTING INTERLOCK = 1
 SERIAL PORT 1
  NAME="GRES COM 1"
 SERIAL PORT 2
  NAME="GRES COM 2"
 SERIAL PORT 3
  NAME="GRES COM 3"
```

```
 SERIAL PORT 4
  NAME="GRES COM 4"
 SERCLK RATE = 4915200
 HI RATE = 4096.0
 LO RATE = 25.6
 SYSTEM RATE=4096
 CLOCK TYPE = MASTER

IO CARRIER
 ADDRESS=0xC2000000
 SLOT=3
 CLOCK MODE=BINARY
 HI RATE = 4096
 SYSTEM RATE=4096
 MEDIUM SYSTEM RATE = 256.0
 LOW SYSTEM RATE = 25.6
 CLOCK TYPE = SLAVE/* " When adding a GRESIII, CLOCK TYPE =
SLAVE " */


DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.21
FILENAME="DUC_53.OUT"
CHANNEL 1 NAME="493.21 DC-Slot 3-1" CONNECTOR="J4"
MODE=DC FILTER=1000

 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.21B
FILENAME="DUCB_53.OUT"
CHANNEL 2 NAME="493.21B AC-Slot 3-2" CONNECTOR="J5"
MODE=AC FILTER=1000

/* Daughter 3 is empty and used for optional boards */

 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT"
CHANNEL 1 NAME="493.14 2SVD-Slot 3-4" CONNECTOR="J7"
RANGE=25 MODE=SINGLE CLAMP=DISABLED
```

```
IO CARRIER
 ADDRESS=0xC2200000
 SLOT=4
 CLOCK TYPE = SLAVE


DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.21B
FILENAME="DUCB_53.OUT"
CHANNEL 1 NAME="493.21B DC-Slot 4-1" CONNECTOR="J4"
MODE=DC FILTER=1000

DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.21
FILENAME="DUC_53.OUT"
CHANNEL 2 NAME="493.21 AC-Slot 4-2" CONNECTOR="J5" MODE=AC
FILTER=1000

/* Daughter 3 is empty and used for optional boards */

 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT"
CHANNEL 1 NAME="493.14 2SVD-Slot 4-4" CONNECTOR="J7"
RANGE=25 MODE=SINGLE CLAMP=DISABLED

 IO CARRIER
 ADDRESS=0xC2400000
 SLOT=5
 CLOCK TYPE = SLAVE


 DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.21B
FILENAME="DUCB_53.OUT"
CHANNEL 1 NAME="493.21B DC-Slot 5-1" CONNECTOR="J4"
MODE=DC FILTER=1000

 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.21B
FILENAME="DUCB_53.OUT"
CHANNEL 2 NAME="493.21B AC-Slot 5-2" CONNECTOR="J5"
MODE=AC FILTER=1000

/* Daughter 3 is empty and used for optional boards */

 DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT"
CHANNEL 1 NAME="493.14 2SVD-Slot 5-4" CONNECTOR="J7"
RANGE=25 MODE=SINGLE CLAMP=DISABLED
```

```
IO CARRIER
 ADDRESS=0xC2600000
 SLOT=6
 CLOCK TYPE = SLAVE


DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.21B
FILENAME="DUCB_53.OUT"
CHANNEL 1 NAME="493.21B DC-Slot 6-1" CONNECTOR="J4"
MODE=DC FILTER=1000

 DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.21B
FILENAME="DUCB_53.OUT"
CHANNEL 2 NAME="493.21B AC-Slot 6-2" CONNECTOR="J5"
MODE=AC FILTER=1000

/* Daughter 3 is empty and used for optional boards */

DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.14
FILENAME="DVD_53.OUT"
CHANNEL 1 NAME="493.14 2SVD-Slot 6-4" CONNECTOR="J7"
RANGE=25 MODE=SINGLE CLAMP=DISABLED


IO CARRIER
 ADDRESS=0xC2800000
 SLOT=7
 CLOCK TYPE = SLAVE


DAUGHTER 1 ADDRESS=0x00000 TYPE=#493.45
FILENAME="A2D_53.OUT"
   CHANNEL 1 NAME="Analog Input 1-Slot 7-1" CONNECTOR="J4"
   CHANNEL 2 NAME="Analog Input 2-Slot 7-1" CONNECTOR="J4"
   CHANNEL 3 NAME="Analog Input 3-Slot 7-1" CONNECTOR="J4"
   CHANNEL 4 NAME="Analog Input 4-Slot 7-1" CONNECTOR="J4"
   CHANNEL 5 NAME="Analog Input 5-Slot 7-1" CONNECTOR="J4"
   CHANNEL 6 NAME="Analog Input 6-Slot 7-1" CONNECTOR="J4"
```

```
DAUGHTER 2 ADDRESS=0x10000 TYPE=#493.46
FILENAME="D2A_53.OUT"
   CHANNEL 1 NAME="Analog Output 1-Slot 7-2" CONNECTOR="J5"
   CHANNEL 2 NAME="Analog Output 2-Slot 7-2" CONNECTOR="J5"
   CHANNEL 3 NAME="Analog Output 3-Slot 7-2" CONNECTOR="J5"
   CHANNEL 4 NAME="Analog Output 4-Slot 7-2" CONNECTOR="J5"
   CHANNEL 5 NAME="Analog Output 5-Slot 7-2" CONNECTOR="J5"
   CHANNEL 6 NAME="Analog Output 6-Slot 7-2" CONNECTOR="J5"


 DAUGHTER 3 ADDRESS=0x20000 TYPE=#493.47
FILENAME="ENC_53.OUT"
CHANNEL 7 NAME="493.47 Encoder-Slot 7-3" CONNECTOR="J6"
MODE=INCREMENTAL

DAUGHTER 4 ADDRESS=0x30000 TYPE=#493.15
FILENAME="D3VD_53.OUT"
CHANNEL 7 NAME="493.15 3SVD-Slot 7-4" CONNECTOR="J7"
CLAMP=DISABLED

DIO TRANSITION BOARD
 TRANSITION SLOT=4
 CONNECTOR = "J3"
  INPUT 1 NAME="Digital Input 1"
  INPUT 2 NAME="Digital Input 2"
  INPUT 3 NAME="Digital Input 3"
  INPUT 4 NAME="Digital Input 4"
  INPUT 5 NAME="Digital Input 5"
  INPUT 6 NAME="Digital Input 6"
  INPUT 7 NAME="Digital Input 7"
  INPUT 8 NAME="Digital Input 8"
  INPUT 9 NAME="Digital Input 9"
  INPUT 10 NAME="Digital Input 10"
  INPUT 11 NAME="Digital Input 11"
  INPUT 12 NAME="Digital Input 12"
  INPUT 13 NAME="Digital Input 13"
  INPUT 14 NAME="Digital Input 14"
  INPUT 15 NAME="Digital Input 15"
  INPUT 16 NAME="Digital Input 16"
 CONNECTOR="J4"
  OUTPUT 1 NAME="Digital Output 1"
  OUTPUT 2 NAME="Digital Output 2"
  OUTPUT 3 NAME="Digital Output 3"
  OUTPUT 4 NAME="Digital Output 4"
  OUTPUT 5 NAME="Digital Output 5"
```

```
  OUTPUT 6 NAME="Digital Output 6"
  OUTPUT 7 NAME="Digital Output 7"
  OUTPUT 8 NAME="Digital Output 8"
  OUTPUT 9 NAME="Digital Output 9"
  OUTPUT 10 NAME="Digital Output 10"
  OUTPUT 11 NAME="Digital Output 11"
  OUTPUT 12 NAME="Digital Output 12"
  OUTPUT 13 NAME="Digital Output 13"
  OUTPUT 14 NAME="Digital Output 14"
  OUTPUT 15 NAME="Digital Output 15"
  OUTPUT 16 NAME="Digital Output 16"


TEMP CONTROL
 TYPE="Eurotherm 2208"
 HOST PORT="GRES COM 1"
 BAUD=9600
 CHANNEL 1 NAME="Temp Control 1" ADDRESS=0x1


RSC
 NAME="RSC 2" HOST PORT="GRES COM 2" FILENAME="POD.HEX"
INTERLOCK=2
 NAME="RSC 3" HOST PORT="GRES COM 3" FILENAME="POD.HEX"
INTERLOCK=3
 NAME="RSC 4" HOST PORT="GRES COM 4" FILENAME="POD.HEX"
INTERLOCK=4
```

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